Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Original Article

School closure during the coronavirus disease 2019 (COVID-19) pandemic – Impact on children's sleep

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ABSTRACT

Objective: To evaluate the sleep habits of school-going children before and during school closure in the national lockdown period (called 'Circuit Breaker' or CB in Singapore) due to the COVID-19 pandemic.
Methods: Cross-sectional, anonymous, online, population-based survey questionnaire was administered to parents aged 21 years and above with children aged between 3 and 16 years attending pre-school, primary or secondary school (equivalent to kindergarten, middle and-high school) and residing in Singapore. Sleep duration in relation to various daily activities including academic activities, physical exercise, and screen time was evaluated pre-CB and during CB.
Results: Data from 593 participants were analyzed. Pre-CB, the overall mean (SD) sleep duration of the study population was 9.01 (1.18) hours on weekdays and 9.99 (0.94) hours on weekends. During CB, mean (SD) sleep duration overall was 9.63 (1.18) hours. Although children generally went to bed later (mean 0.65 h later), they woke up even later during CB (mean 1.27 h later), resulting in longer sleep duration (mean increase of 0.35 h). This was most evident in secondary school children (mean increase of 0.70 h). Children attending private schools (which had later start times) had increased sleep duration (mean 10.01 (SD 0.89) hours pre-CB and 10.05 (SD 0.93) hours during CB) compared to public schools (mean 9.05 (SD 0.91) pre-CB and 9.49 (SD 1.22) hours during CB).
Conclusions: School closure from the COVID-19 pandemic resulted in longer sleep duration in school-going children. Early school/academic activity start times had a significant impact on limiting children's sleep duration.

1. Introduction

Sleep is essential for the health and well-being of all children. It has been well-established that sleep deprivation in children can cause functional and cognitive impairment [1–5]. The effects of inadequate sleep includes increased risk of chronic diseases, behavioural difficulties, and poorer memory and executive function skills [6,7]. Studies from across the world have demonstrated that children from Asian countries, including Singapore, sleep less than the recommended number of hours each day [8–10].

Factors such as screen time [11], video games, internet and online gaming as well as other social media use [12] are reported to delay sleep times and overall sleep quantity. Even parental work hours and schedules [13,14] have shown to contribute to earlier waking times in children. More importantly, school related factors such as early school start times [15], school academic demands [16] and homework [17] as well as long curriculum hours and co–curricular activities have all been suggested to be mediators of sleep-wake timings as well as duration of sleep in children [17,18].

The COVID-19 pandemic that emerged in the month of January 2020, led to the lockdown of cities and countries, restricting the movement of people. This has also led to major disruptions in daily activities, resulting in significant changes in the routines of parents and children. The need for social distancing and staying indoors presents a multitude of factors that can impact on children and adolescents, and the true extent of sleep disruption is still being discovered as

Abbreviations: Circuit Breaker, CB.

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the pandemic continues. A recent editorial by Becker and Gregory [19] outlined the possible implications of the COVID-19 pandemic on child and adolescent sleep habits, and the need to conduct research on sleep habit changes in these unprecedented times, as there may be the potential of some of these changes having a lingering effect on sleep habits, for example, insomnia, once normality returns.

On the one hand, the need for staying indoors reduces sunlight exposure and exposes children to increased use of screen time as the need for home schooling and parental work at home increases. As school routines are disrupted, flexibility in sleep and wake times and potential loss of strict bedtime routines may compound these effects and potentially lead to negative effects on sleep. The pandemic may also affect older children and adolescents differently. Singapore is typical of East Asian countries where adolescents chronically lack sleep in the pursuit of academic excellence, and have high levels of anxiety [20]. The effects of moving to home-schooling and staying indoors as part of social distancing policies as a result of the pandemic may exacerbate sleep issues through the increased use of online networking at home, reduced physical activity, and the lack of enforced school routines. On the other hand, some children may well get more sleep with the elimination of school travel time and the opportunity for later waking, which may conversely benefit adolescents who naturally have a delayed circadian phase.

On 7th April 2020, the Singapore government instituted a national lockdown called the 'Circuit Breaker' (CB) in the combat against the evolving COVID-19 pandemic. The CB period ended on 1st June 2020. This mandated the cessation of all but essential services and workplaces. Schools were closed with effect from 8th April 2020 and all pre-schools, schools and institutes of higher learning switched to home-based e-learning mode. Consequently, all school-going children and adolescents did not have to commute to school, parents (apart from those engaged in essential services) worked from home and all stores and recreational facilities were shut. This was an unprecedented situation which provided a unique opportunity to help understand how sleep habits in children are influenced by the daily social environment. It provided an opportunity to study sleep habits when factors that worked against getting sufficient sleep (such as early school start times) were eliminated.

The education system in Singapore starts with pre-school, moves through primary (age 7–12) and secondary school, age 13–16 (equivalent to kindergarten, middle and high school respectively) before the start of tertiary education at the age of 16–18 years. There are two main categories of schools – public (local) schools and private (international) schools. Although the two schools differ in many aspects, the main difference in context of this paper is the schools' start times. Public schools generally start between 7:30–7:45am, and private schools start between 8:00–9:00am. This study will help to determine how much of an influence changes in school schedules have on sleep in children. In addition, other possible disruptors such as home-based learning, time spent on academic activities, and changes in the amount of screen time will also inform about how sleep habits are affected by these changes. In this study, we aim to evaluate the sleep habits and patterns at baseline (pre-CB) and during CB of school-going children. This study hypothesizes that the absence of early school start times will enable school-going children to achieve a higher sleep quantity (largely through later morning wake times) and ultimately increase total sleep time and overall better daytime function.

2. Materials and methods

2.1. Design

This is a cross-sectional study of participants from an open survey questionnaire during the national CB period from 7th April 2020 to 1st June 2020. Inclusion criteria were that of parents aged 21 years and above with children aged between 3 and 16 years attending preschool, primary or secondary school and residing in Singapore. Eligible participants were recruited via email flyers, advertisements on social media (Facebook), and messaging platforms (WhatsApp). The recipients of the survey questionnaire link were encouraged to disseminate the invitation to other eligible contacts. Implied consent was obtained when participants completed the voluntary anonymous questionnaire.

The study was reviewed for ethical considerations and approved by the hospital's institutional Domain Specific Review Board.

2.2. Study measure

The study questionnaire (please see Supplementary material) was hosted on a secure online platform (form.gov.sg) and included questions on demographic data (ie education profile of the child, the participant's relationship with the child and the type of household they lived in), sleeping patterns of children and parents, and the time the child spent on various daily activities. Separate questions were asked to ascertain information on sleep timings and daily activities over two time periods: pre-CB and CB. Information on home-based learning start times, screen time (including mobile phones, tablets, and internet use for activities other than schoolwork and learning) and physical exercise were also obtained. Respondents were asked on their perception of the child's sleep and to rank the factors that impacted on sleep during the CB period.

2.3. Analysis

All returned questionnaires were analyzed. Descriptive statistics were used to examine sleep data during pre-CB and CB. Analysis was also stratified based on children's school level (pre-school, primary school, and secondary school) and type of school (public or private) by comparing the mean difference of sleep hours across groups. Average sleep duration per day was calculated for pre-CB by averaging the weekday and weekend sleep duration using formula (5 x average weekday duration + 2 x average weekend duration)/7.

Data was analysed with SPSS Statistics version 26 (IBM) using chi-square, t-test and other parametric and non-parametric tests as applicable.

3. Results

3.1. Response rate

There was a total of 603 participants. Ten participants did not meet the age cut-off of 21 years and aborted the survey without completing it. Hence, data from 593 participants were analyzed in this study. The survey questions were designed to mandate a response for each question, so all survey questionnaires were fully completed and there were no missing data from completed surveys. Characteristics of the respondents and the children are presented in Table 1.

3.2. Sleep duration pre-CB and during CB

Pre-CB, sleep duration was longer on weekends, with a shorter duration on weekdays. The overall mean (SD) sleep duration of the study population was 9.01 (1.18) hours on weekdays and 9.99 (0.94) hours on weekends. During CB, their average sleep per day was closer to that on pre-CB weekends, contributing to an overall longer daily sleep duration during CB with a mean (SD) sleep duration overall of 9.63 (1.18) hours (Fig. 1).

Table 1
Characteristics of the participants and children.

Characteristics	N = 593
Respondents	
Mother, n (%)	510 (86)
Father, n (%)	83 (14)
Number of people living in the same household	
Adults, median (IQR)	3 (2–3)
Children, median (IQR)	2 (1–2)
Type of housing	
Public housing, n (%)	248 (41.8)
Private apartment/condominium, n (%)	234 (39.5)
Private landed property, n (%)	96 (16.2)
Others, n (%)	15 (2.5)
CHILDREN	
Age, years, median (IQR)	8 (6–11)
School level	
Preschool, n (%)	139 (23)
	Median age 4 years (IQR 3–5)
Primary School, n (%)	336 (57),
	Median age 8 (IQR 7–10)
Secondary School, n (%)	118 (20)
	Median age 14 (IQR 13–15)
Type of School	
Public, n (%)	445 (75)
Private, n (%)	148 (25)
Fixed start time to home-based learning during CB	
Yes, n (%)	369 (62)
No, n (%)	224 (38)

There was a significant difference in the sleep duration between that of pre-CB (on both weekdays and weekends) and during CB for the whole study population (Table 2, Fig. 1).

3.3. Sleep duration at different school levels: pre-schoolers, primary schoolers and secondary schoolers

Secondary school students had significantly shorter sleep duration compared to students in primary school pre-CB (mean 8.12 h and 9.39 h respectively, $p < 0.05$) and during CB (mean 8.32 h and 9.89 h respectively, $p < 0.05$) (Table 2).

The overall mean (SD) change in sleep duration from pre-CB to CB was +0.34 (0.82) hours. When the distribution of sleep duration was compared across the different school levels, all three categories have significant increase in sleep hours between pre-CB and during CB (Fig. 2). The magnitude of increase in sleep hours was significantly different across the three groups of children (ANOVA $F = 17.51$, $p < 0.01$). For preschool children, the mean (SD) change in sleep duration was +0.09 (0.71) hours. For primary school children, it was +0.51 (0.79) hours, and for secondary school children, it was +0.20 (0.93) hours.

3.4. Sleep duration between private and public school

Irrespective of the period, whether pre-CB or during CB, children in private schools had longer sleep duration compared to those in public schools. In pre-CB, mean (SD) sleep duration in hours on weekdays for private school children was 9.92 (0.99) hours and for public school children it was 8.70 (1.08) hours. When school routines were removed during pre-CB weekends and during CB, sleep duration in children from public schools increased with a consequent reduced difference in sleep duration between public and private school children. For pre-CB weekends, the mean (SD) sleep duration (in hours) for private school children was 10.24 (0.88) hours and for public school children it was 9.90 (0.95) hours. During CB, the mean (SD) sleep duration was 10.05 (0.93) hours for private school children and 9.49 (1.22) hours for public school children.

3.5. Impact of fixed start time to home-based learning on sleep duration during CB

When the data was analyzed at school level, pre-school children were less likely to have fixed start times to home-based learning during CB (30%) compared to primary and secondary school children (66% and 89% respectively). The presence or absence of a fixed start time to home-based learning did not have a significant effect on the sleep duration of pre-school or primary school children from pre-CB to CB (Fig. 3). However, among children in secondary school, those who did not have fixed start times showed a larger gain in sleep duration (mean (SD) increase of 0.74 (1.26) hours) from pre-CB to CB compared to those who had fixed start times to their home learning (mean (SD) increase of 0.13 (0.88) hours).

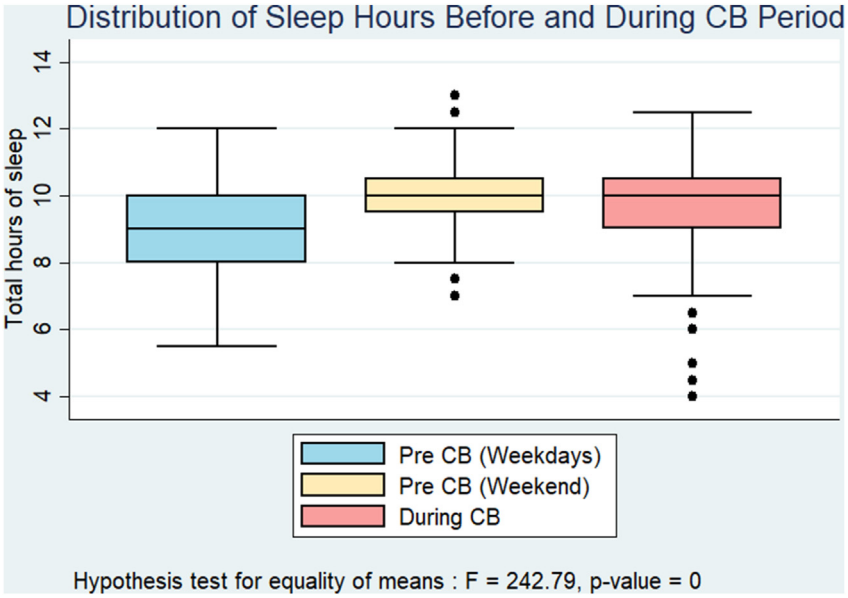

Fig. 1. Difference in sleep hours – CB vs Pre CB: whole study population.

Table 2
Sleep patterns pre and during Circuit Breaker.

	Pre-CB (Weekday)[1]	Pre-CB (Weekend)[2]	Pre-CB average (Average of weekdays and weekends)[3]	During CB	P value [1]Weekday vs CB) [2]Weekend vs CB) [3]Pre-CB average vs CB)
CHILD					
Bedtime, mean (SD) time in hours	21:25 (1.02)	22:05 (0.67)	21:36 (1.02)	22:05 (1.25)	[1]0.000 [2]0.885 [3]0.000
Wake time, mean (SD) time (in hours)	6:25 (0.67)	8:05 (1.11)	6:54 (0.58)	7:49 (0.90)	[1]0.000 [2]0.000 [3]0.000
Total duration of sleep in hours, mean (SD)	9.01 (1.18)	9.99 (0.94)	9.29 (1.00)	9.63 (1.18)	[1]0.000 [2]0.000 [3]0.000
Pre-school					
Bedtime, mean (SD) time in hours	21:36 (1.04)	21:36 (0.92)	21:18 (1.18)	21:42 (1.18)	[1]0.000 [2]0.028 [3]0.000
Wake time, mean (SD) time in hours	7:06 (0.67)	7:48 (0.88)	7:18 (0.65)	7:48 (0.95)	[1]0.000 [2]0.225 [3]0.000
Total duration of sleep in hours, mean (SD)	10:0 (0.80)	10.02 (0.93)	10.00 (0.75)	10.1 (0.85)	[1]0.029 [2]0.228 [3]0.149
Primary- school					
Bedtime, mean (SD) time in hours	21:12 (0.82)	21:54 (0.95))	21:24 (0.82)	21:48 (1.08)	[1]0.000 [2]0.500 [3]0.000
Wake time, mean (SD)time in hours	6:18 (0.46)	8:00 (1.03)	6:48 (0.44)	7:42 (0.89)	[1]0.000 [2]0.000 [3]0.000
Total duration of sleep in hours, mean (SD)	9.11 (0.89)	10.10 (0.87)	9.39 (0.75)	9.89 (0.94)	[1]0.000 [2]0.000 [3]0.000
Secondary School					
Bedtime, mean (SD) time in hours	22:30 (0.96)	23:12 (1.05)	22:42 (0.93)	23:06 (1.24)	[1]0.000 [2]0.164 [3]0.000
Wake time, mean (SD) time in hours	6:06 (0.58)	8:42 (1.29)	6:48 (0.60)	7:30 (0.83)	[1]0.000 [2]0.000 [3]0.000
Total duration of sleep in hours, mean (SD)	7.60 (0.97)	9.44 (1.06)	8.12 (0.85)	8.32 (1.19)	[1]0.000 [2]0.000 [3]0.024

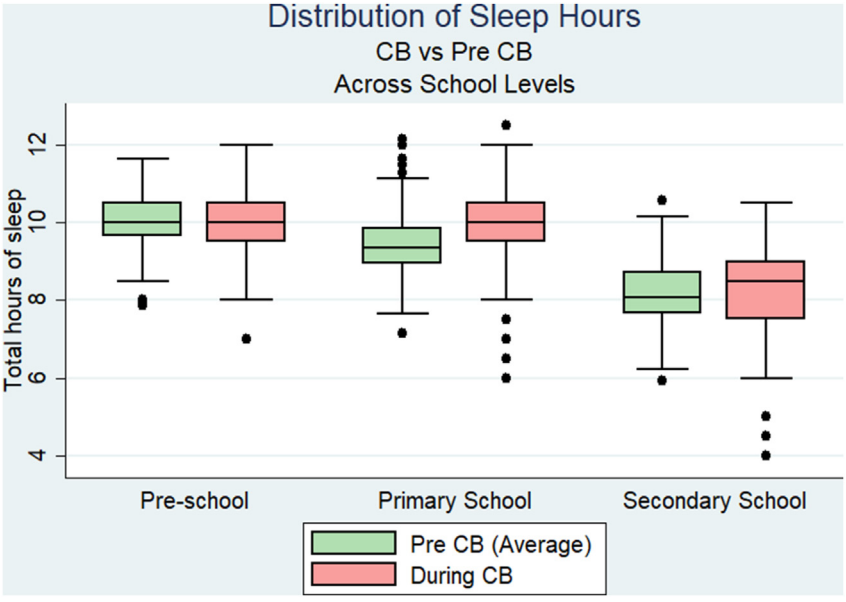

Fig. 2. Sleep duration based on level of school: Pre-school children, primary school children and Secondary school children.

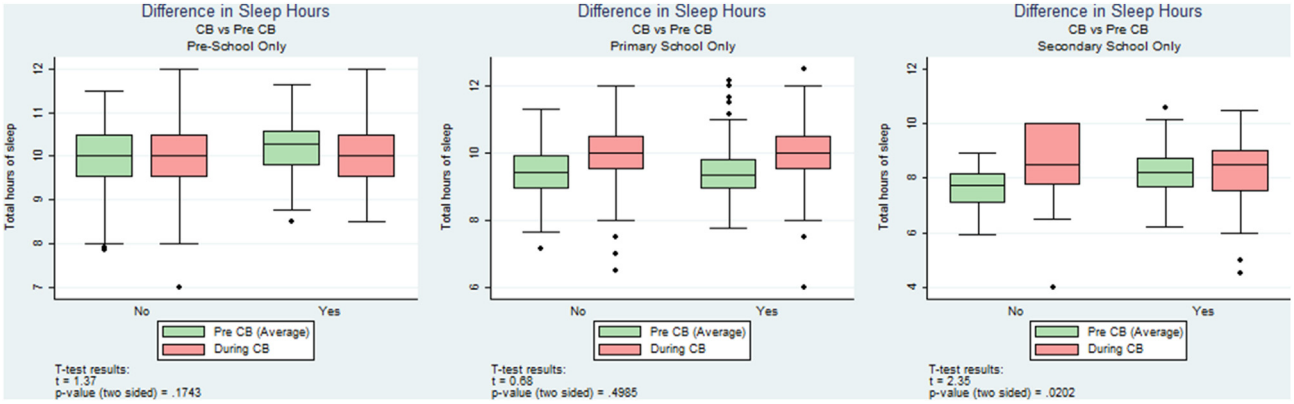

Fig. 3. Impact of fixed start time to home-based learning on sleep duration: Level of schooling.

For the 369 participants who reported a fixed start time to home-based learning, most (40.8%) reported a start time of 8:00am. The modal start time for pre-schoolers was 9:00am and 10:00 am (22.0% each); primary schoolers, 8:00am (45.5%); and secondary schoolers, 8:00am (44.3%).

3.6. Academic activities

The mean (SD) time spent on academic activities by children across all schools and levels was 7.07 (2.57) hours pre-CB and 4.62 (2.55) hours during CB. Private school students across all levels spent a mean (SD) of 6.36 (2.69) hours on academic activities pre-CB and 3.15 (2.51) hours during CB. In contrast, public school students spent a mean (SD) of 7.18 (2.65) hours on academic activities pre-CB and 5.01 (2.34) hours during CB.

The correlation between time spent on academic activities and sleep duration pre-CB and during CB was $r^2 = -0.27$ ($p < 0.01$) and $r^2 = -0.36$ ($p < 0.01$) respectively.

3.7. Physical exercise

The mean (SD) time spent on physical exercise by children across schools and levels was 1.13 (0.60) hours pre-CB and 0.91 (0.73) hours during CB. The reduction in time spent on physical exercise was similar at all school levels.

The correlation between time spent on physical exercise and sleep duration pre-CB and during CB was $r^2 = 0.03$ ($p = 0.47$) and $r^2 = 0.13$ ($p < 0.01$) respectively. One possible explanation is that 114 children did no exercise on average during CB, compared to 44 children pre-CB. As a result of the increase in the number of children doing no exercise and the reduced amount of exercise done overall during CB, any change in exercise amount may have had a greater effect on sleep duration in this period.

3.8. Non-academic screen time

The mean (SD) time spent on non-academic screen time in all children was 1.61 (1.17) hours pre-CB and 3.15 (2.19) hours during CB. Pre-school children spent a mean (SD) of 1.05 (0.76) hours on non-academic screen time pre-CB and 2.49 (1.77) hours during CB. Primary school children spent a mean (SD) of 1.26 (0.94) hours on screen time pre-CB and 2.91 (2.03) hours during CB. Secondary school children spent a mean (SD) of 2.56 (1.61) hours on non-academic screen time pre-CB and 4.40 (2.62) hours during CB.

The correlation between non-academic screen time and sleep duration pre-CB and during CB was $r^2 = -0.41$ ($p < 0.01$) and $r^2 = -0.34$ ($p < 0.01$) respectively.

3.9. Parental perception of factors affecting sleep in children during CB

Based on parental perception, the removal of school start time, no travelling time to/from school and increased internet time were the top three factors affecting their children's sleep as reported by 72%, 72% and 60% of parents respectively. Half of parents (50.6%) reported that their child slept better during CB while 42.3% felt there was no change in their child's sleep, and 7.1% reported worse sleep. Of those that reported better sleep, 44.0% reported that their children woke up more refreshed, 26.6% reported that their children were less tired in the day, and 10.4% reported that their children were more energetic. In the minority who reported worse sleep, reasons included more moody behaviour, less daytime napping, increased bed-wetting, and, particularly in children aged 6–8 years, increased nightmares.

4. Discussion

The enforced national school closure during CB because of the COVID-19 pandemic meant that children and their families had to rapidly adapt to changes from school-based to home-based learning on a massive scale. This resulted in changes to children's routines in many ways.

The results of our study reveal that there was significant change in sleep duration during CB when schools were closed, and learning shifted to the home. Children went to bed later but woke up even later, with a net increase in total sleep time in the whole study population. This difference was significant among primary and secondary school children. However, there was little impact on the hours of sleep in pre-school children. Our study also shows that pre-CB, children had more sleep during weekends compared to weekdays. The increased sleep duration during weekends was likely due to the absence of the regular school routine present during weekdays. Differences in sleep duration on weekdays compared to weekends in school-age children is well-known, and our data supports this fact that traditional schooling results in considerably less sleep on weekdays [21]. The difference between weekday and weekend sleep was greatest in secondary school children, consistent with other findings suggesting that in this age group, delayed sleep phase syndrome, increased academic demands and early school start times can impact significantly on adolescent sleep [22]. The average sleep duration during CB approximates the sleep duration of pre-CB weekends, reflecting that in the absence of time pressures from the usual school routines, the weekend sleep durations seen pre-CB are possibly more representative of what the child really needs.

The American Academy of Sleep Medicine recommends that preschoolers get 10–13 h of sleep daily, primary school children 9–12 h, and secondary school children 8–10 h [23]. Our study shows that our population of children in Singapore generally got less sleep than these recommendations, as reflected by the spread of sleep duration hours at each school level, even during CB. This is consistent with findings in other studies on Asian children [8].

In Singapore, private schools start their school day later in general when compared to public schools. Our data show that private school children get more sleep on average during school days compared to their public school counterparts. Interestingly, sleep duration on pre-CB weekdays among private school children was closer to their pre-CB weekend sleep duration, suggesting that private school hours did not significantly impact on their sleep, and that the decrease in pre-CB weekday sleep we saw in our school-age children overall was contributed mostly by public school children who had earlier school start times. This supports the evidence that later school start times is a factor in increased sleep duration for children, and that the CB period acted as a leveller to improve sleep quantity, particularly among public school children [24].

There is evidence from our data showing if fixed start times (which were mostly set at 8am) were removed from the home-learning schedule during the CB period, children slept more than those who continued having fixed start times to learning. The increase in sleep hours was particularly significant among secondary school children when fixed start times were removed for their home-based learning. The artificially imposed routines of school timetables on normal physiological sleep requirements in adolescents (which is a later sleep time) would be even more disruptive than for younger children. There is a natural delay in sleep onset to a later time from puberty onwards, due to changes in circadian and homeostatic sleep regulation in adolescence [25]. These findings were consistent with parental perceptions in the study that the removal of school start time and the absence of commuting time to/from school were the most considered factors affecting sleep in their children.

When exploring the relationship further between time spent on academic activities and sleep, the amount of time spent on academic activities was inversely related to sleep duration in children even during the CB period, and this was more striking in the older group of children in secondary schools, highlighting the role of academic burden on sleep. There was a significant increase in screen time among all age groups, from pre-schoolers to secondary school children during the CB. There was also a significant reduction in physical activities during the CB period among the primary and secondary school children. Essentially, due to restrictions in going outdoors during the COVID-19 crisis, and an increased presence at home as a result, an unhealthy lifestyle of increased screen time and reduced exercise was adopted.

4.1. Limitations

The survey did not prevent multiple entries from the same individual; the assumption was that each participant responded only once on receipt of the survey invite. We chose to collect data separately for the weekdays and weekends during the pre-CB period because we wanted to study the effects on children's sleep on weekdays with the usual school timetables in place. With this routine changed during CB, we collected the average sleep duration across the week for this period, and therefore did not differentiate weekdays and weekends for the CB period. We did not collect data on co-morbid conditions in children which may influence their sleep.

The study uses a cross-sectional design, where parents retrospectively report on the child's sleep habits, and we acknowledge that reporting retrospectively on their children's sleep times may reflect time in bed rather than time to actual sleep and does not capture sleep efficiency in a way that tools such as actigraphy would. Questionnaires are also subject to recall bias, as any retrospective tool would. However, given the unprecedented circumstances of an enforced lockdown provided by a global pandemic, collection of data on sleep habits prior to CB period retrospectively allowed us to make direct comparisons of sleep before the COVID-19 pandemic's impact on the household and during the CB as a result of the pandemic. Whilst the use of retrospective parent report of sleep data for children, including adolescents, is not uncommon [26–28], we acknowledge that parental reporting may lead to over- or under-estimation of their children's sleep time and time spent on activities. However, younger children would not have the capacity to self-complete the questionnaires, so for the sake of consistency, we applied the same parental questionnaires to both the younger and older groups of children and adolescents, with the assumption that participants completed the questionnaires as accurately as they could. Lastly, as pointed out by Becker and Gregory [19], sleep data collected during the COVID-19 pandemic may not be directly extrapolatable to other situations in which children have online classes without physically going to school. However, it can also be presumed that even during non-pandemic times, later school/class start times would result in longer sleep duration for children, and possibly even be more so in the absence of other pandemic-related stressors.

5. Conclusions

The shift to home-based learning because of nation-wide closure of schools from the COVID-19 pandemic resulted in longer sleep duration in school-age children, with the greatest change in older children (secondary school children). School start times, time spent commuting to and from school, and internet usage were perceived by parents to be the biggest factors affecting sleep in their children. Delaying school start times can help children achieve their required duration of sleep.

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CRediT authorship contribution statement

Michael Teik Chung Lim: Methodology, Investigation, Writing - original draft, Project administration. **Mahesh Babu Ramamurthy:** Methodology, Formal analysis, Investigation, Writing - review & editing, Project administration. **Ramkumar Aishworiya:** Methodology, Formal analysis, Investigation, Writing - review & editing, Project administration. **Dimple D. Rajgor:** Methodology, Investigation, Writing - review & editing, Project administration. **Anh Phuong Tran:** Investigation, Data curation, Visualization, Writing - review & editing, Project administration. **Prerana Hiriyur:** Data curation, Formal analysis, Visualization, Writing - review & editing. **Shangari Kunaseelan:** Methodology, Investigation, Writing - review & editing, Project administration. **Majid Jabri:** Methodology, Investigation, Writing - review & editing, Project administration. **Daniel Yam Thiam Goh:** Conceptualization, Methodology, Investigation, Writing - review & editing, Project administration.

Conflict of interest

None.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2020.12.025.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2020.12.025.

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