Original research

Validation of the Chinese Version of the Children's ChronoType Questionnaire (CCTQ) in School-aged Children

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Abstract

The Children's ChronoType Questionnaire (CCTQ) is a valid and reliable measure for assessing prepubertal children aged 4-11 years. The CCTQ is a parent-reported, 27-item questionnaire consisting of sleep-wake parameters for scheduled and free days (16 items), a morningness/eveningness scale (M/E, 10 items), and a five-point, single-item, chronotype score. The CCTQ has been translated into different languages, but a Chinese version is not available. In the present study, we aimed to produce a Chinese version of the CCTQ and test its validity and reliability on school-aged children. A total of 555 children aged 7-11 years were recruited from five primary schools. The parents were told to complete the CCTQ and record their child's sleep pattern in a 7-day sleep diary. Sixty-six children and their parents were invited to participate in determining the test-retest reliability of the CCTQ over a 2-week interval, and their sleep patterns were assessed using a sleep diary. The internal consistency of the Chinese CCTQ M/E score as measured by Cronbach's alpha was acceptable (0.74). Regarding the test-retest reliability of the instrument, moderate to strong Spearman's correlation coefficients were found for most of the CCTQ – sleep-wake items (ρ = 0.52 – 0.86) and for the CCTQ-M/E total score (ρ = 0.78). For the concurrent validity, Spearman's correlations between the sleep-wake parameters of the CCTQ and the sleep diary were moderate to high on both the scheduled days (ρ = 0.54 to 0.87) and free days (ρ = 0.36 to 0.60). For the correlations measured with actigraphs, significant correlations were found in the CCTQ sleep-wake parameters, including bedtime, get-up time, sleep latency, sleep period, time in bed, and mid-sleep point on both the scheduled (ρ = 0.31 to 0.76) and free days (ρ = 0.27 to 0.52), but not in sleep latency and sleep period on free days. The results of the present study suggest that the Chinese version of the CCTQ is a reliable and valid tool for assessing chronotypes in Chinese school-aged children in Hong Kong.

KEYWORDS: Circadian rhythms, Chronotype, Sleep, Children, Validation, School-aged, Hong Kong Chinese

Introduction

Chronotype refers to an individual's preference for morning versus evening activities (Guthrie et al. 1995). It also refers to the time of day when individuals are "at their best" (Kerkhof 1985; Werner et al. 2009) or feel "the best rhythm" (Horne and Östberg 1976; Roenneberg et al. 2003). An individual's chronotype can be described as morning-type, evening-type, or intermediate-type. People who are morning types (also called "larks") have an earlier sleep schedule (Carskadon et al. 1993; Horne and Östberg 1976; Kerkhof and Lancel 1991; Mecacci and Zani 1983), and report fewer difficulties with sleepiness and attention (Giannotti et al. 2002) than evening types; while people who are evening types ("owls") report more daytime sleepiness, a greater variation in sleep times and bedtimes, and more time spent in bed (DeYoung et al. 2007; Giannotti et al. 2002; Randler 2011; Roeser et al. 2012; Taillard et al. 1999; Tzischinsky and Shochat 2011). Eveningness is also associated with depression (de Souza and Hidalgo 2014; Pabst et al. 2009), low mood (Diaz-Morales et al. 2015), and poor academic performance in children and adolescents (Preckel et al. 2013; Rahafar et al. 2016). Children and adolescents who are evening types are more likely to perform poorly in school (Preckel et al. 2013; Rahafar et al. 2016), exhibit behavioral problems such as aggression (Schlarb et al. 2014) and procrastination (Digdon and Howell 2008), and be less conscientious (Tonetti et al. 2009) than those who are morning types. Chronotype is not only linked to biological and psychological functioning but is also associated with negative health consequences. Evening-type individuals have been found to be at an elevated risk of developing diabetes, hypertension, fibromyalgia (Kantermann et al. 2012; Merikanto et al. 2013), mood disorders, and eating disorders (Adan et al. 2012).

Childhood sleep problems, such as bedtime resistance, sleep onset delay, prolonged nighttime awakenings, and difficulty waking in the morning affect approximately 25% of children in pediatric primary care, with more than half reporting either daily or weekly occurrences (Honaker and Meltzer 2016). These sleep problems may be attributed to a mismatch between the children's circadian characteristics and their parents' expectations or family and school schedules (Jenni and O'Connor 2005; Takeuchi et al. 2001). Therefore, a better understanding of chronotypes in children is critical to helping children, parents, and educators to better cope with their sleep problems or adjust their expectations of their children's performance.

Despite the importance of studying chronotypes, there is little information on the development, distribution, and variability of chronotypes in children. Because a child's report may contain insufficient information about their sleep duration (Werner et al. 2008), both a parents' report and a self-reported measure should be employed concurrently to obtain a more accurate picture of a child's sleep pattern. Werner and colleagues (Werner et al. 2009) developed a parents' report assessment – the Children's ChronoType Questionnaire (CCTQ). The CCTQ was adapted from the Munich Chronotype Questionnaire (MCTQ) (Roenneberg et al. 2003) and the Morningness/Eveningness Scale for Children (MESC) (Carskadon et al. 1993). The CCTQ has been shown to be a valid and reliable measure for prepubertal children aged 4–11 years (Werner et al. 2009). It has also been widely used in studies of chronotypes in prepubertal children (Doi et al. 2016; Durmuş et al. 2017; Jafar et al. 2017; Tarakçioğlu et al. 2018).

The CCTQ has been translated into Japanese (Ishihara et al. 2014) and Turkish (Dursun et al. 2015), but a Chinese version is not available. In view of the increasing attention being paid to chronotypes in children, it is time to come up with a validated Chinese version of the CCTQ, to give parents, clinicians, researchers, educators, and decision-makers a useful tool for studying chronotypes in Chinese populations. The aim of our study, then, was to validate a Chinese version of the CCTQ and test its validity and reliability on school-aged children.

Materials and methods

Participants

Parents of children aged 7-11 attending the second to fifth grades at five primary schools in the Hong Kong SAR were given an information sheet and invited to participate in this study, together with their child. If two or more children were from the same family, we included only one child based on random selection to avoid double counting a subject's response in the validation analysis. Parents were excluded from the study if they were unable to comprehend traditional Chinese characters. Ethic approval was obtained for this study from the institutional review board of the Hong Kong Polytechnic University (Ref: HSEARS20170124003-01).

Procedures

This study was conducted in three phases: (1) translation of the CCTQ, (2) CCTQ validation, and (3) examination of the test-retest reliability of the CCTQ and an actigraphic study.

The first phase was the translation of the CCTQ into a Chinese version. Permission to translate the CCTQ into Chinese was obtained from the author of the CCTQ (Werner et al. 2009). The translation process followed the guidelines put forward by the World Health Organization (Harkness et al. 2008): (1) forward translation, (2) review by an expert panel, (3) back-translation, (4) second review by the expert panel, (5) pretesting and cognitive interviewing. The original version of the CCTQ was first translated by a researcher (WY). The first translated CCTQ was then reviewed by an expert panel comprised of the original translator and experts in the area of sleep (WY, KC, YH). The panel reviewed the translated version to identify and resolve any weaknesses in it, such as inadequately translated expressions or concepts. Afterwards, the translated version was back translated by another researcher (YY) who had not previously been involved in the effort and was unfamiliar with the original English CCTQ. The two versions were compared and the translation was revised. The translation underwent a further review by the expert panel until a satisfactory version was produced that reflected the original version.

After being reviewed by the expert panel, a convenience sample of 12 Cantonese-speaking Hong Kong residents who were parents of primary school children were invited to complete the translated Chinese version of the CCTQ. The research personnel conducted an item-by-item cognitive debriefing interview with each individual. The cognitive debriefing covered the clarity of the items, the interpretation of their meaning, and any suggestions on how to reword unclear, inappropriate, or irrelevant words or phrases. Discrepancies between interpretations and the intended meanings of the original version were highlighted, and the translated version was revised accordingly to clear up any ambiguities or misunderstandings. The language structure and grammar were then edited according to feedback from the cognitive debriefings, and a finalized Chinese version of the CCTQ was produced.

In the second phase of the study, written consent was obtained from the parents prior to their participation. We provided a package containing an information sheet explaining the purpose of the study, a consent form, and a set of questionnaires to teachers at five primary schools to distribute to parents from May 2017 to June 2018. The parents could choose to participate in the first phase of the study only or in both phases. A total of 1,723 children and their parents were invited to fill in a set of questionnaires. The questionnaires included the Chinese version of the CCTQ, a parent-reported sleep diary, and a questionnaire on the parents' socio-demographic background and their children's sleep habits. They were told to record their child's sleep pattern daily in the sleep diary for 7 days. When the seventh day of the sleep diary was filled in (1 week later), they were instructed to fill in the CCTQ. A total of 555 completed Chinese version of the CCTQ were returned.

The parents were given the telephone contact details of research personnel who could be contacted if they had any questions on the study or questionnaires. The signed consent forms and the completed questionnaires were returned to the school.

In the third phase of the study, 72 children and their parents agreed to participate. They were asked to again fill in the CCTQ 2 weeks after they had first completed it, for the purpose of examining the test-retest reliability of the instrument, and to complete a 7-day sleep diary for their child. During the 7-day recording period, their child was told to wear an actigraph. Details of the administration of actigraphs are given in the Measures section. Finally, 3 children were found to be older than 11 and 3 parents failed to return the questionnaire and hence were excluded. A total of 66 parents were included in the test-retest analysis. The interval between the 2 assessment time points was exactly 14 days for all of the included retest samples. Among the 66 parent-child pairs, 4 did not complete at least 5 nights of actigraphy and were excluded from the analysis. Finally, 62 children's actigraphy data were analyzed.

Measures

The Children's ChronoType Questionnaire (CCTQ)

The CCTQ (Werner et al. 2009) is a 27-item, parent-reported questionnaire for assessing individual differences in chronotype. The CCTQ consists of three measures: 16 items on sleep patterns (items 1 to 16), 10 items of a morningness/eveningness score (M/E score; items 17 to 26), and a single-item chronotype score (CT; item 27). The first 16 items on sleep patterns assess sleep-wake parameters recorded on weekdays (scheduled days, items 1 to 8) and weekends/holidays (free days, items 9 to 16), such as time in bed, sleep latency, sleep period (differences between sleep onset in the evening and wake-up time in the morning), and sleep inertia (time from waking up to becoming fully alert). The mid-sleep point on free days (MSF) is calculated as the midpoint of the sleep period on free days only; whereas the MSF corrected for the sleep debt accumulated through scheduled days (MSFsc) is the averaged sleep periods of 5 scheduled days and 2 free days. A child's chronotype was determined using the M/E score, which was derived by adding up the individual scores from answers to 10 questions (items 17 – 26, with reversed items 17, 18, 24, and 25) to obtain a total score ranging from 10 to 48, to indicate the proneness from extreme morningness to extreme eveningness. An individual who scored 23 points or below would be classified as a morning type (M-type); one who scored 24-32 would be deemed an intermediate type (N-type), and one who scored 33 or above would be regarded as an evening type (E-type). Finally, the single-item CT was reported by parents, who were asked to give the best description of their child's circadian phase preference from among five categories ranging from 1 (definitely a morning type) to 5 (definitely an evening type). The English version of the CCTQ demonstrated satisfactory test-retest reliability on the sleep-wake parameters (r = 0.58 to 0.94) and high test-retest reliability on the MSF (r = 0.91), MSFsc (r = 0.79), M/E (r = 0.94), and CT (r = 0.84) scores (Werner et al. 2009). A Cronbach's alpha of 0.81 and item-total correlations of 0.31 to 0.71 were reported for the M/E scores (Werner et al. 2009).

Sleep diaries

The parents were given a sleep diary to record their child's sleep pattern on a daily basis for 7 consecutive days, which is considered long enough to capture the night-to-night variabilities in sleeping habits (Buysse et al. 2006). Major open-ended questions on sleep parameters were extracted from a consensus sleep diary (Carney et al. 2012), which included the parents' record of their child's bedtimes and rising times, and the parents' best estimate of their child's sleep start time and end time, sleep latency, wake time after sleep onset (wake time after initial sleep), and total sleep time (estimation of sleep duration from "lights out" at night to the time of rising next morning, and excluding daytime sleep). For these questions, the parents were told to write down the time and the number of minutes or hours. Nocturnal sleep period was calculated by the difference between the estimated sleep start time and sleep end time, without excluding nocturnal wake times. The parents were also told to record the number and duration of their child's naps and dozes. There was an item asking whether the child was sick on that day. If the parent reported that the child was sick on that day, the sleep diary and actigraphic data for that day were discarded to prevent contamination. The parents would be asked to record data for additional days to compensate for the loss of data on days due to sickness. If the parents failed to complete the 7-day sleep diary and replace such loss of data, they would be excluded from the analysis of sleep diary. To narrow down the variations in the number of weekend nights among the surveyed children, we distributed sleep diaries and actigraphs according to the schools' academic calendar to ensure that there were no more than 3 free days during the recorded period. Typically, there were 5 scheduled days (usually a weekday) and 2 free days (usually on a weekend) during the 7-day recording period for sleep diaries and actigraphs.

Actigraphy

Children whose parents had agreed to participate were home-monitored with an actigraph. Actigraphs (Ambulatory Monitoring, Inc., Ardsley, NY) are watch-like devices that record physical movements by means of an accelerometer-microprocessor link. Since movement correlates with wakefulness and lack of movement with sleep (Ancoli-Israel et al. 2003; Lichstein et al. 2006), wrist actigraphy has been used to objectively estimate sleep. The parents were told to put the actigraph on their child's non-dominant wrist 30 minutes before bedtime and leave it there until 30 minutes after the child wakes up in the morning for 7 consecutive nights. They were instructed to press the actigraph event marker to indicate the lights-out and morning rising times. The actigraphs were used to collect objective sleep data to estimate the sleep start time, sleep end time, total sleep time, and total wake time using 1-minute epochs. The Zero-Crossing Mode was used to quantify wrist movements and the data were analyzed using ACTION3 proprietary software (Ambulatory Monitoring, Inc., Ardsley, NY). If the actigraph was off for all or part of the night, the actigraphic and sleep diary data for that night were discarded.

Statistical analysis

All statistical analyses were performed using SPSS version 23.0 for Windows (SPSS, Chicago, USA). Non-parametric tests were used due to skewed distribution of the data. The sleep-wake parameters calculated from items 1-16 of the CCTQ were presented in medians and interquartile ranges, and compared across three groups of children with different chronotypes (M-type, N-type, and E-type) by the Kruskal-Wallis test with post-hoc analyses. The internal consistency of items 17 to 26 of the Chinese version of the CCTQ was evaluated using Cronbach's alpha (Tavakol et al., 2011). The homogeneity of the scale was assessed by an item-total correlation. Test–retest reliability over a 2-week interval was assessed using Spearman's correlation. The concurrent validity of the CCTQ items on sleep-wake parameters (items 1-16) with subjective and objective sleep measures were examined. This was done by correlating the scores with the sleep-wake parameters on the free days and scheduled days, as obtained from the parent-reported sleep diary and the actigraphs using Spearman's correlation.

Results

In the second phase of the study, 555 children were recruited. The mean age of the children at the time of the assessment was 9.32 years (SD = 1.11, range: 7-11 years), and 46.8% of them were girls. More than a half of the children were the first-born child in their family. The median of their bedtime and getting up time were 9:51PM and 07:01AM on scheduled days and 10:37PM and 8:59AM on free days, respectively. They slept an average of 8 h 42 min per night on scheduled days and 9 h 48 min per night on free days. More socio-demographic information on the included children and their families is presented in the Supplementary Table.

Table 1 shows comparisons of the children's sleep-wake parameters according to their chronotype, as reported by their parents (CCTQ items 1 to 16). There were significant differences among those of different chronotypes in the timing of their sleep–wake parameters on both scheduled days and free days (All $P < 0.05$), with the exception of sleep period and sleep latency on free days. Post-hoc pairwise comparisons showed that children of the E-type had significantly later bedtimes, sleep onset times, wake-up times, get-up times, mid-sleep points and sleep inertia than those of the M-type and N-type on both scheduled and free days (All $P < 0.05$), with the exception of the comparison between the N-type and E-type in sleep inertia. The differences in these sleep-wake parameters were greater on free days than on scheduled days. The sleep–wake parameters of time in bed (P

< 0.001), sleep period (P < 0.001), and sleep latency (P = 0.02) for the three chronotypes were significantly different on scheduled days; whereas on free days, only with regard to time in bed (P = 0.002) was a significant difference observed, but not in sleep period and sleep latency. Post-hoc pairwise comparisons showed that, on scheduled days, the time in bed and sleep period of the E-type children were significantly shorter than those of the children of the M-type and N-type (All P < 0.05), and shorter in sleep latency than the N-type (P < 0.05), but on free days, the time in bed of the E-type children was significantly longer than that of the M-type and N-type children (All P < 0.05). No differences in the duration of sleep period and sleep latency were found among the three chronotype groups.

Internal consistency

The Cronbach's alpha of the 10 CCTQ-M/E items (items 17 to 26) was 0.74. The item-total correlations using Spearman's correlation ranged from 0.28 to 0.50 (Table 2). The elimination of each item did not lead to any substantial increase in the internal consistency of the scale.

Test–retest reliability

A total of 69 children and their parents were invited for the test-retest evaluation, but only 66 pairs provided sufficient data and were included in analysis. More than 80% of the parents in the test-retest sample were female (12 males, 54 females), but the gender distribution was more even among the children (37 boys, 29 girls). The mean ages of the parents and children were 40.36 years (SD = 6.22, range: 26-60 years) and 9.09 years (SD = 1.13, range: 7-11 years), respectively. The Supplementary Table shows additional details on the included families.

Over a 2-week interval, the CCTQ-M/E showed high test-retest reliability ($\rho = 0.78$), while the CCTQ-MSFsc showed moderate test-retest reliability ($\rho = 0.60$) (Table 3). High test-retest reliability was also demonstrated for the mid-sleep point on both scheduled days ($\rho = 0.79$) and free days ($\rho = 0.79$). Test-retest Spearman correlations were in the rage of 0.64

to 0.86, for reports about lights-off times, sleep onset times, wake-up times, and get-up times on both scheduled and free days. Moderate test-retest Spearman correlations (range: 0.56 to 0.75) were found for sleep period, time in bed, and sleep inertia on both scheduled and free days. High correlation was observed for bedtime (ρ = 0.83) on scheduled days, but only moderate correlations were found in sleep latency (ρ = 0.57) on scheduled days, and bedtime and sleep latency on free days (ρ = 0.61 and 0.52). In contrast, high test-retest Spearman correlations for time fully alert were seen on both the scheduled days (ρ = 0.80) and free days (ρ = 0.84).

Concurrent validity

There were significant correlations between the sleep-wake parameters measured by the CCTQ with the variables obtained from the parent-reported sleep diary (Table 4). The Spearman's correlations between the sleep-wake parameters of the CCTQ and the sleep diary were generally higher on the scheduled days (range: 0.54 to 0.87) than on the free days (range: 0.36 to 0.60). On scheduled days, the Spearman's correlations between the sleep diary and the sleep-wake parameters of the CCTQ were at least 0.70, with the exception of the sleep latency (ρ = 0.54) and sleep period (ρ = 0.67). On free days, moderate Spearman's correlations were only observed for the bedtime (ρ = 0.55), get-up time (ρ = 0.55) and mid-sleep points (ρ = 0.60), while small correlations were seen for the other sleep-wake parameters.

For the correlations measured with actigraphs, significant correlations were found in the CCTQ sleep-wake parameters, including bedtime, get-up time, time in bed, and mid-sleep point on both scheduled and free days. Sleep latency and sleep period on scheduled days (ρ = 0.31 and 0.39) were weakly correlated but were still significant.

Discussion

The present study provides evidence that the Chinese version of the CCTQ is a reliable and valid tool for assessing chronotypes in school-aged children in Hong Kong. Our findings demonstrated that there were significant differences in the sleep-wake schedules of the M-, N-, and E-type children. According to the M/E scale scores of the CCTQ, E-type children had significantly later bedtimes, sleep onset times, wake-up times, get-up times, and mid-sleep points than the N-type children, who in turn had significantly later times than the M-type children. Time in bed and sleep period were significantly shorter for the E-type children than for the N-type children, and also shorter for the N-type than for the M-type children. However, such differences were less obvious in sleep latency. These findings are almost consistent with those reported in previous studies in which CCTQ-M/E scores were used to compare sleep-wake parameters across chronotypes in preschool children and toddlers (Doi et al. 2016; Ishihara et al. 2014; Simpkin et al. 2014).

Our results show that the Chinese version of the CCTQ possesses internal reliability. The Chinese version of the CCTQ had a Cronbach's alpha of 0.74, which is consistent with the original CCTQ (Cronbach's alpha = 0.81) (Werner et al. 2009), the Japanese version of the CCTQ (Cronbach's alpha's = 0.77) (Ishihara et al. 2014), and the Turkish version of the CCTQ (Cronbach's alpha = 0.65) (Dursun et al. 2015). The 2-week test-retest Spearman's correlations on the sleep-wake parameters in this study ranged from moderate to high, and were generally lower than those found in the study conducted in Switzerland to validate the original version of the CCTQ. The discrepancy may be due to methodological and socio-cultural differences between our study and our participants and those of the original CCTQ in Switzerland. In the Swiss study, the participants were provided with a bookshop certificate as a monetary incentive, which may have encouraged them to put more effort into filling in the questionnaire, resulting in a higher response rate and better-quality data (Werner et al. 2009; Werner et al. 2008). In addition, their studies included children aged from 4 to 11, who were much younger than our sample (6-14 years old). Another other possible explanation was that there may have been public or school holidays between the 2-week intervals, which might have affected the children's sleep habits, resulting in lower test-retest correlations. However, we scheduled the data collection period to be 1 month after the start of the semester, to avoid overlaps with some important school events, e.g. examinations, so that the data that were collected would reflect the children's usual sleeping/waking habits.

Our results showed that the Spearman's correlations between the CCTQ's sleep-wake parameters and the sleep diary were generally higher on the scheduled days (range: 0.54 to 0.87) than on the free days (range: 0.36 to 0.60), which is in line with the findings by Werner et al (Werner et al. 2009). This is possibly due to a higher variability in the children's sleep-wake patterns on free days than on scheduled days. In addition, similar to the study by Werner (Werner et al. 2009), a relatively lower Spearman's correlation in sleep inertia was observed in our study, possibly because the children's behavior may have been more variable due to some daily events, leading to greater variations in sleep inertia across the test-retest period. Another possible explanation is that the children may have been awakened at different stages of sleep across the study period, which may have affected the results on sleep inertia. An experimental study showed that the reaction time of children slowed significantly if they were awakening from the second stage 4 sleep cycle, especially in the case of children aged 6-7 years (Splaingard et al. 2007).

We found that most of the CCTQ sleep-wake-items showed a moderate to high correlation with the parent-reported sleep diary on scheduled days, while the correlations were generally lower on free days. The correlation between the CCTQ's sleep-wake-items and the actigraphic measures was high for bedtime, get-up time, and mid-sleep point and moderate for time in bed on scheduled days, while only relatively weak correlations were found on free days. Weak but significant correlations were only found for sleep latency and sleep period on scheduled days, while no correlation was found on free days. In an agreement study by Werner et al. (Werner et al. 2008), which used a self-constructed questionnaire to obtain sleep parameters, agreement rates between the actigraphs and the questionnaire as well as between the diary and the questionnaire were insufficient for all variables. They had reflected that this result was obtained because, unlike the actigraphy and diary data, the questionnaire obtained information about normal sleep-wake patterns but not data about a specific day in the week. Our actigraphic findings are consistent with those from the study conducted by Ishihara et al. (2014), who also found moderate to high correlations in bedtime and mid-sleep point and a relatively low correlation in sleep latency; however, they also demonstrated a moderate correlation in sleep period. This shows a discrepancy between objective actigraphic and CCTQ measures in sleep latency, which indicates that it may be difficult for the parents to precisely estimate their child' sleep latency. In addition, a weaker correlation was observed in our sample when compared with the results by Ishihara (Spearman $\rho = 0.51$). In the study by Ishihara, preschool-aged (3-6 years) children were included, whereas our study included school-aged children. A possible explanation is that the parents may have closely monitored their child's sleep during the child's preschool years, resulting in a stronger correlation between parent-reported sleep latency and the actigraph found in their study.

There are some limitations to our study. The study data were collected in only five primary schools and more than 1000 parents did not participate in the study, probably due to time-demanding nature of this study and lack of incentive. Therefore, the socio-demographic characteristics of the parents of the children attending these schools might not be representative of the general population. Moreover, we did not include any assessments of the pubertal development. Sleep patterns will change with pubertal development (Randler and Bilger, 2009). As we planned to use the CCTQ to study the chronotype in a particular age group rather than in a specific stage of growth and development, we did not exclude those who were pubertal. We did not include assessment on the children's co-sleep information which may affect their sleep-wake pattern (Palmer et al., 2018). Further studies may include assessment on co-sleeping pattern to explore its effect on chronotypes. Finally, although we planned to ask the parents to indicate when their child was sick and to record additional days in the sleep diary to compensate, we found that the logistics of the present study made this plan unfeasible, as the teachers would collect the questionnaires from all of the participants on the same date. Therefore, if a child was sick, the child's parents would fail to complete the 7-day sleep diary or they simply did not return the sleep diary; hence, they were hence not included in the analysis and the number of incomplete sleep diary due to sickness is unclear, which might lower the generalizability of the findings.

In conclusion, our results suggest that the Chinese CCTQ is a reliable and valid measure for assessing chronotypes in school-aged children between the ages of 7 and 11. We therefore propose that the Chinese CCTQ be used in future studies to investigate the chronotypes of school-aged children. Future studies should be conducted to evaluate the validity of the Chinese CCTQ in pre-school aged children.

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Table 1. Comparisons of Children's ChronoType Questionnaire (CCTQ) assessments of the sleep-wake parameters of school-aged children according to chronotype (N=555)

Sleep-wake parameters	M-type (N=60)		N-type (N=354)		E-type (N=141)		*P*-value [#]	Post-hoc pairwise comparison
	Median	IQR	Median	IQR	Median	IQR		
Scheduled days								
Timing								
Bedtime	21:07	0:30	21:45	0:45	22:30	0:40	<0.001	M<N***, M<E***, N<E***
Sleep onset time	21:32	0:48	22:06	0:55	22:45	0:55	<0.001	M<N***, M<E***, N<E***
Wake-up time	6:35	0:43	7:00	0:30	7:10	0:30	<0.001	M<N***, M<E***, N<E***
Get-up time	6:40	0:45	7:01	0:34	7:15	0:25	<0.001	M<N***, M<E***, N<E***
Mid-sleep point	2:05	0:37	2:33	0:35	2:53	0:35	<0.001	M<N***, M<E***, N<E***
Duration								
Time in bed (mins)	570	44	550	50	540	62	<0.001	M>N**, M>E***, N>E*
Sleep period (mins)	542.5	41	525	51	505	55	<0.001	M>N***, M>E***, N>E**
Sleep latency (mins)	10	9	10	10	10	8	0.02	M>N, M>E, N>E*
Sleep inertia (mins)	5	8	10	10	15	10	<0.001	M<N**, M<E***, N<E***
Free days								
Timing								
Bedtime	22:00	0:30	22:30	1:00	23:00	1:00	<0.001	M<N***, M<E***, N<E***
Sleep onset time	22:10	1:04	22:48	0:45	23:30	0:55	<0.001	M<N***, M<E***, N<E***
Wake-up time	7:50	1:30	8:30	1:15	9:30	1:30	<0.001	M<N***, M<E***, N<E***
Get-up time	8:00	1:20	9:00	1:25	9:40	1:30	<0.001	M<N***, M<E***, N<E***
Mid-sleep point	2:56	0:53	3:47	0:55	4:30	1:06	<0.001	M<N***, M<E***, N<E***
Duration								
Time in bed (mins)	610	84	615	85	630	90	0.002	M<N, M<E*, N<E**
Sleep period (mins)	585	76	587.5	70	605	73	0.07	/
Sleep latency (mins)	10	14	10	10	10	15	0.14	/
Sleep inertia (mins)	5	19	15	25	15	25	0.001	M<N*, M<E**, N<E
MSFsc	9:12	0:41	9:04	0:42	8:55	0:48	0.001	M>N*, M>E**, N>E

[#] Kruskal-wallis test was adopted in group comparison.

*: $P<0.05$, **: $P<0.01$, ***: $P<0.001$; MSFsc: mid-sleep point on free days corrected for the sleep debt accumulated through scheduled days.

Table 2. Internal consistency of the Morningness/Eveningness (M/E) Scale of the Children's ChronoType Questionnaire (CCTQ) for school-aged children (N=555)

Items	Mean	SD	Corrected item-total correlation [a]	Cronbach's Alpha [b]
17	2.08	0.96	0.46	0.71
18	2.30	0.89	0.41	0.72
19	3.43	0.84	0.41	0.72
20	4.09	0.72	0.40	0.72
21	1.60	0.64	0.28	0.74
22	3.20	0.99	0.40	0.72
23	4.23	0.72	0.31	0.73
24	2.87	1.18	0.50	0.71
25	2.50	1.23	0.45	0.72
26	2.99	0.87	0.44	0.72
All				0.74

[a] Spearman's correlation; [b] Cronbach's alpha coefficients if each item deleted.

Table 3. Test-Retest Reliability within 2 weeks of the sleep-wake parameters reported in the Children's ChronoType Questionnaire (CCTQ) (N=66)[#]

	Scheduled days	Free days
Bedtime	0.83***	0.61***
Time of lights-off	0.82***	0.64***
Sleep latency	0.57***	0.52***
Sleep onset time	0.78***	0.65***
Wake-up time	0.86***	0.78***
Get-up time	0.85***	0.79***
Time fully alert	0.80***	0.84***
Sleep period	0.75***	0.56***
Time in bed	0.71***	0.69***
Sleep inertia	0.65***	0.61***
Mid-sleep point	0.79***	0.79***
MSF_{SC}	0.60***	
M/E score	0.78***	

[#] Spearman correlation was used in test-retest analysis.

*: *P*<0.05, **: *P*<0.01, ***: *P*<0.001; MSFsc: mid-sleep point on free days corrected for the sleep debt accumulated through scheduled days; M/E: Morningness/Eveningness.

Table 4. Agreement between the sleep/wake parameters measured by the Children's ChronoType Questionnaire (CCTQ) and the sleep diary and actigraphy (N=62) [#]

Sleep-wake parameters	CCTQ	
	Scheduled days	Free days
Parent-reported sleep diary		
Bedtime	0.79***	0.55***
Get-up time	0.87***	0.55***
Sleep latency	0.54***	0.43***
Sleep period	0.67***	0.36**
Time in bed	0.77***	0.44***
Mid-sleep point	0.79***	0.60***
Objective measure- actigraphy		
Bedtime	0.76***	0.47***
Get-up time	0.72***	0.52***
Sleep latency	0.31*	0.03
Sleep period	0.39**	0.09
Time in bed	0.61***	0.27*
Mid-sleep point	0.72***	0.33**

[#] Spearman correlation was performed.

*: P<0.05, **: P<0.01, ***: P<0.001.

Supplementary Table. Descriptive statistics of socio-demographic information of interviewed children and their parents

	All sample (N=555)	Retest sample (N=66)
Marital status		
Married	411 (76.3)	48 (73.8)
Single-parenting*	128 (23.7)	17 (26.2)
Refuse to answer	16	1
Education level of parents		
Primary education/no schooling	18 (3.4)	0 (0.0)
Secondary education	383 (71.3)	53 (80.3)
University	136 (25.3)	13 (19.7)
Refuse to answer	18	/
Family income		
No income or CSSA#	71 (13.5)	15 (22.7)
Below HKD$ 25000^	288 (54.8)	33 (50.0)
HKD$ 25000 - $ 50,000	116 (22.1)	12 (18.2)
HKD$ 50,001 or above	51 (9.7)	6 (9.1)
Refuse to answer	29	/

* Single-parenting included divorced parents, widowhood and single (not getting married).

CSSA, Comprehensive Social Security Assistance scheme, which is the safety net provided by the HKSAR government for those with insufficient financial resources.

^ **The** median monthly domestic household income of the HKSAR at the time of study conducted. (Ref: Census and Statistics Department, the HKSAR 2017. 2016 Population By-census. Thematic Report: Household Income Distribution in Hong Kong. Hong Kong: Census and Statistics Department)