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Non-School Day Catch-Up Sleep among Pupils in Japan

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Abstract

Backgrounds: Weekend catch-up sleep is the difference in sleep duration between the weekend and weekdays, and reflects sleep debt, whose significance is hypothesized to be altered by weekday sleep duration. This study aimed to assess this hypothesis. **Methods:** Multiple-comparison tests and multiple-regression analyses were conducted on questionnaires asking various lifestyle habits obtained from 2722 pupils in grades 5 to 12 and stratified by groups of pupils with shorter (≤7 hours) or longer (>7 hours) sleep duration on the nights before schooldays. **Results:** The percentage of pupils in negative non-school day catch-up sleep category was 6.6%, whereas that in non-school day catch-up sleep > 2 hours was 14.4%. In comparison with the reference category (non-school day catch-up sleep of zero), multiple comparison tests on lifestyle habits revealed significantly longer screen time in the shorter sleep-duration group of pupils with negative non-school day catch-up sleep and those with non-school day catch-up sleep > 2 hours. This analysis also demonstrated a significantly longer screen time in the longer sleep-duration group of pupils with non-school day catch-up sleep > 2 hours. Physical activity in pupils with negative non-school day catch-up sleep in the longer sleep-duration group was significantly longer, while that in pupils with non-school day catch-up sleep > 2 hours in the shorter sleep-duration group was significantly shorter. In the longer sleep-duration group, pupils with non-school day catch-up sleep > 2 hours showed poorer academic performance. Multiple regression analysis revealed that longer physical and after-school activities were significantly associated with non-school day catch-up sleep decrease in both the study groups. In the longer sleep-duration group, male gender, shorter screen time, and higher standardized body mass index were significantly associated with decreased non-school day catch-up sleep. **Conclusions:** Sleep duration before school days contributed differently to the non-school day catch-up sleep evaluation.

Keywords

Academic Performance, Body Mass Index, Physical Activity, After-School

Activity, Screen Time

1. Introduction

Between 25% and 84% of adolescents suffer from sleepiness, with most of their sleepiness originating from insufficient sleep [1]. Insufficient sleep has adverse effects on adolescent well-being and daytime functioning, including: decreased cognitive functioning, emotional regulation, and academic performance, along with increased behavior problems, the risk of accidents, and deleterious effects not only on immune systems but also on various metabolic systems [2]. The association between a shortage of sleep and obesity is well-known [3].

The perceived daily sleep needs of adolescents increase progressively from the first half of the school week to the second half [4]. Moreover, the sleep debt of adolescents might increase across weekdays (school days) and might reduce during the weekend (non-school day). Thus, several adolescents may catch up on their sleep loss, which increases during weekdays (school days) by increasing their sleep duration during the weekend (non-school day). This difference between the weekend (non-school day) and weekdays (school days) in the sleep duration constitutes weekend "catch-up sleep" (CUS), which is considered a reflection of the sleep debt [4] [5] [6]. Wolfson and Carskadon [7] reported that a longer CUS was associated with worse academic performance, Kuula *et al.* [8] failed to demonstrate constant associations between CUS and neurocognitive function, and Leak *et al.* [9] reported the association of long CUS with better academic performance in male students. Thus, no consistent finding of the association of CUS with academic performance has been reported. Similarly, reports of the association of CUS with obesity are inconclusive [10] [11] [12], and no definitive conclusion has been obtained for the association of CUS with screen time [13] [14] [15] [16]. To solve these inconsistent results on CUS, the recent literature on adolescents' weekend CUS has hypothesized that the same weekend CUS value with different weekday sleep duration produced alternative outcomes, whereby weekend CUS might be assessed in association with the weekday sleep duration [17] [18] [19], although weekend CUS is reported to be associated with better health outcomes among adults [20].

This study aimed to assess the hypothesis that sleep duration before school days contributed differently to non-school day CUS (nSDCUS) evaluation, by analyzing the current status of nSDCUS among adolescents in Japan.

2. Materials and Methods

This study was part of a survey conducted between October 2016 and November 2018 [21] [22] [23]. The study questionnaire was handed to students in grades 5 to 12 at 28 public schools (15 elementary schools, 8 junior high schools, and 5 senior high schools) by their schoolteachers. A letter assuring students that their

responses would be treated anonymously and confidentially and that participation in the study was voluntary was delivered together with the questionnaire. Schoolteachers collected the written consent (signed by a guardian) for participation in this study along with the completed questionnaires, and these documents were sent to the author. Of the 4208 questionnaires distributed, 2722 questionnaires with complete responses were returned with an agreement to participate in the study.

The participants self-reported their grade and sex (male = 1, female = 2) as well as their height and weight, which were used to calculate body mass index (BMI). The gender- and grade-standardized BMI were calculated for the analysis. With regard to the bedtime and waking times, the participants were asked to select one of the nine 1-hour interval categories (bedtime: from 1. before 20:00 to 9. after 3:00; waking time: from 1. before 5:00 to 9. after 12:00). The representative times of each category were determined as their mean time (bedtime: 19:30, 20:30…2:30, 3:30; waking: 4:30, 5:30, …, 11:30, 12:30). Participants were asked about these bedtimes and waking times on both school days and non-school days separately, and the times were used to calculate social jetlag (SJL, which was defined as the difference of the midpoint of night sleep on the nights before non-school day and school day). Furthermore, these times were used to calculate the night-time sleep duration of the night before the school days and the non-school days separately. These sleep durations were used to calculate the nSDCUS. The average sleep duration per day was calculated as: Daily average sleep duration = {[(sleep duration before school days) × 5] + [(sleep duration before non-school days) × 2]}/7.

Self-reported academic performance (1) very good, 2) good, 3) not good, or 4) poor), sleepiness during school class: 1) never, 2) sometimes, 3) often, and 4) always), and several lifestyle habits (breakfast, defecation, after-school activity, physical activity, and screen time) were assessed. The frequency of eating breakfast: 1) always, 2) often, 3) sometimes, or 4) never) and defecating: 1) every day, 2) every other day, 3) once every 2 - 3 days, or 4) twice a week or less), hours of after-school activity per week, the number of days engaged in physical activity per week, and daily screen time on both school days and non-school days were ascertained. Screen time comprises the time expended on various media devices (television, video, video game, digital versatile disc, computer, tablet, mobile [cell] phone, smartphone). For determining the screen time, the participants were asked to select one of five 2-hour interval categories (from 1) < 2 hours to 5) ≥ 8 hours) on both school days and non-school days separately. The representative times of each category were determined as their mean time (1 hour, 3 hours, … 9 hours). Thereafter, the average screen time per day was calculated as follows: Daily screen time = {[(screen time before school days) × 5] + [(screen time before non-school days) × 2]}/7.

According to the lower appropriate sleep duration value for school-age children and teenagers described by the National Sleep Foundation [24], the sleep duration of the night before school days was divided into two categories by 7

hours. The nSDCUS was divided into five categories (negative, 0, 0 - 1, 1 - 2, or >2 hours). The Student's *t*-test was used to determine any significant difference in the examined factors between those whose sleep duration on the night before school days was 7 hours or less (shorter sleep group [SSG]) and more than 7 hours (longer sleep group [LSG]) in each nSDCUS category. Mann-Whitney's U test was used to assess the difference of distribution among five nSDCUS categories between SSG and LSG. Dunnett's multiple-comparison test (DMCT) was used to determine significant differences in the examined factors among the nSDCUS categories in each school day sleep-duration category by setting 0 nSDCUS category as the reference group according to the method previously reported by Lv *et al.* [19].

Furthermore, to determine the factors associated with nSDCUS, multiple regression analysis (MRA) was conducted by setting nSDCUS as a dependent variable with grade, gender, standardized BMI, sleepiness during school class, frequency of breakfast eating and defecating, hours of after-school activity per week, the number of days engaged in physical activity per week, average daily screen time, self-reported academic performance, and sleep duration before school days as the explanatory variables. According to former studies cited [18] [19] [20], these analyses were also conducted in the SSG and LSG, separately.

In this study, the analysis was restricted to findings with a $P < 0.05$ with more than a small size effect (Cohen's $d > 0.20$ for the *t*-test and DMCT; adjusted $R^2 > 0.02$ for multiple regression analysis) [25]. These analyses were conducted using the software program BellCurve for Excel.

This study was approved in 2016 by the Committee for Medical Research Ethics of Tokyo Bay Urayasu Ichikawa Medical Center (approval no. 199).

3. Results

Table 1 shows the distribution of factors that were examined after stratification by sleep duration on the night before school days and nSDCUS, with results obtained on the DMCT. The percentage of pupils with LSG was 55.8%. The rates of pupils in each nSDCUS category of negative, 0, 0 - 1, 1 - 2, and >2 hours were 6.6%, 26.2%, 33.8%, 19.1% and 14.4%, respectively. The distribution of pupils among the five nSDCUS categories showed significant difference between SSG and LSG ($P < 0.01$). A percentage of pupils with nSDCUS < 2 hours in the SSG (304/1204 = 25.2%) was higher than that in the LSG (87/1518 = 5.7%), while that of negative nSDCUS in the SSG (44/1204 = 3.7%) was lower than that in the LSG (135/1518 = 8.9%).

As shown in Table 1, pupils in the SSG had significantly higher grade, later bedtime, earlier waking time, longer non-school days' sleep duration, longer weekly sleep duration, longer SJL, poorer self-reported academic performance, more sleepiness, longer after-school activity, more breakfast skipping and longer screen time than those in the LSG.

In the following session, results on DMCT in comparison with the reference category were described focusing on pupils with negative nSDCUS and those

Table 1. The distribution of factors that were examined after stratification by sleep duration on the night before school days in each non-school day catch-up sleep category, with results obtained on the Dunnett's multiple comparison test.

Factors	Sleep duration before school days	Non-school day catch-up sleep duration					Total
		<0	0 (Reference)	0 - 1	1 - 2	>2 hrs.	
Number (%)	≤7 hrs.	44 (1.6%)	217 (8.0%)	359 (13.2%)	280 (10.3%)	304 (11.2%)	1204 (44.2%)
	7 hrs.<	135 (5.0%)	495 (18.2%)	561 (20.6%)	240 (8.8%)	87 (3.2%)	1518 (55.8%)
Grade	≤7 hrs.	9.2, 1.8	9.4, 1.7	9.3, 1.8	9.2, 1.8	9.4, 1.8	9.3, 1.8
	7 hrs.<	6.9, 1.7	6.6, 1.5	6.7, 0.7	6.7, 1.5	7.1**, 2.0	6.7, 1.6
	P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Gender (male = 1, female = 2)	≤7 hrs.	1.3, 0.5	1.4, 0.5	1.5**, 0.5	1.5**, 0.5	1.6**, 0.5	1.5, 0.5
	7 hrs.<	1.3**, 0.5	1.4, 0.5	1.5**, 0.5	1.6**, 0.5	1.6**, 0.5	1.5, 0.5
	P value	0.05<	0.05<	0.05<	0.05<	0.05<	0.05<
Bedtime before school days	≤7 hrs.	23.8, 1.0	23.6, 0.9	23.7, 0.9	23.9**, 0.9	24.2**, 1.0	23.9, 0.9
	7 hrs.<	21.7, 0.9	21.8, 0.7	22.1**, 0.7	22.3**, 0.6	22.3**, 0.7	22.0, 0.7
	P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Bedtime before non-school days	≤7 hrs.	24.9**, 1.2	24.0, 1.1	23.9, 1.2	24.0, 1.2	24.3**, 1.3	24.1, 1.2
	7 hrs.<	22.7**, 1.1	22.3, 0.9	22.4, 0.9	22.5, 0.9	22.5, 1.0	22.4, 0.9
	P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Waking time on school days	≤7 hrs.	6.1, 0.7	6.1, 0.7	6.2, 0.8	6.4**, 0.7	6.3**, 0.7	6.3, 0.7
	7 hrs.<	6.7*, 0.7	6.5, 0.5	6.5, 0.5	6.6, 0.5	6.6, 0.6	6.6, 0.5
	P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Waking time on non-school days	≤7 hrs.	6.1, 0.8	6.5, 1.0	7.4**, 1.1	8.5**, 1.1	9.9**, 1.3	8.1, 1.7
	7 hrs.<	6.4**, 0.9	7.0, 0.8	7.8**, 0.8	8.7**, 0.8	10.0**, 1.1	7.7, 1.2
	P value	<0.05	<0.01	<0.01	<0.01	0.05<	<0.01
Sleep duration before non-school days (hrs.)	≤7 hrs.	5.2**, 1.0	6.5, 0.7	7.5**, 0.7	8.5**, 0.7	9.6**, 1.1	8.0, 1.5
	7 hrs.<	7.7**, 0.8	8.7, 0.6	9.4**, 0.5	10.3**, 0.5	11.5**, 0.7	9.3, 1.1
	P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Averaged sleep duration a day (hrs.)	≤7 hrs.	6.0**, 0.8	6.5, 0.7	6.8**, 0.7	7.1**, 0.7	7.1**, 0.8	6.9, 0.8
	7 hrs.<	8.6, 0.8	8.7, 0.6	8.7, 0.6	8.8**, 0.5	9.2**, 0.5	8.8, 0.6
	P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Social jetlag (hrs.)	≤7 hrs.	0.6, 0.6	0.4, 0.7	0.7**, 0.7	1.1**, 0.7	1.8**, 0.8	1.0, 0.9
	7 hrs.<	0.3, 0.9	0.5, 0.6	0.8**, 0.6	1.2**, 0.6	1.8**, 0.7	0.8, 0.7
	P value	0.05<	p<0.05	0.05<	0.05<	0.05<	<0.01
Self-reported academic performance (1, very good, …, 4, poor)	≤7 hrs.	2.7, 0.9	2.6, 0.8	2.5, 0.8	2.6, 0.9	2.6, 0.8	2.6, 0.8
	7 hrs.<	2.4, 0.8	2.3, 0.8	2.3, 0.8	2.3, 0.7	2.6**, 0.8	2.3, 0.8
	P value	NS	<0.01	<0.01	<0.01	0.05<	<0.01

Continued

Standardized BMI	≤7 hrs.	0.3, 1.4	0.1, 1.0	0.0, 0.9	0.0, 1.0	0.0, 1.0	0.0, 1.0
	7 hrs.<	0.0, 1.1	0.0, 1.0	−0.1, 1.0	−0.1, 0.9	−0.1, 1.1	0.0, 1.0
	P value	0.05<	0.05<	0.05<	0.05<	0.05<	0.05<
Sleepiness during class (1, never, …, 4, always)	≤7 hrs.	2.5, 0.9	2.3, 0.9	2.3, 0.8	2.2, 0.9	2.4, 0.9	2.3, 0.9
	7 hrs.<	1.8, 0.7	1.7, 0.7	1.7, 0.7	1.8, 0.6	2.0**, 0.7	1.7, 0.7
	P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
After-school activity (hrs./week)	≤7 hrs.	9.5, 10.2	7.9, 10.1	8.3, 9.1	7.2, 8.0	6.6, 8.1	7.6, 8.9
	7 hrs.<	6.6*, 6.6	5.1, 6.3	4.2, 5.0	3.7**, 4.9	4.4, 5.9	4.6, 5.7
	P value	0.05<	<0.01	<0.01	<0.01	<0.01	<0.01
Physical activity (days/week)	≤7 hrs.	4.5, 2.7	4.3, 3.0	3.5**, 3.1	2.9**, 3.0	2.0**, 2.7	3.2, 3.1
	7 hrs.<	4.1*, 2.6	3.4, 2.7	2.9, 2.7	2.5**, 2.7	2.7, 2.8	3.1, 2.7
	P value	0.05<	<0.01	<0.01	0.05<	<0.05	0.05<
Breakfast taking (1, always, …, 4, never)	≤7 hrs.	1.6, 0.8	1.3, 0.7	1.2, 0.6	1.3, 0.6	1.4, 0.7	1.3, 0.7
	7 hrs.<	1.2, 0.5	1.1, 0.4	1.1, 0.4	1.1, 0.5	1.3**, 0.7	1.1, 0.4
	P value	<0.01	<0.01	<0.01	<0.05	0.05<	<0.01
Defecation frequency (1. every day,….4, twice a week or less)	≤7 hrs.	1.7, 1.0	1.5, 0.8	1.6, 0.9	1.7, 0.9	1.7, 0.9	1.7, 0.9
	7 hrs.<	1.6, 0.8	1.6, 0.8	1.6, 0.9	1.6, 0.8	2.0**, 1.0	1.6, 0.9
	P value	0.05<	0.05<	0.05<	0.05<	<0.05	0.05<
Averaged screen time a day (hrs.)	≤7 hrs.	4.1**, 2.5	2.9, 1.9	2.9, 1.9	3.1, 1.7	3.6**, 2.0	3.2, 1.9
	7 hrs.<	2.4, 1.5	2.2, 1.9	2.5**, 1.5	2.6**, 1.5	2.9**, 1.7	2.5, 1.5
	P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Except for lines for numbers, the average and standard deviation value of each factor were described before and after comma. P value from the results of *t*-test investigating difference of examined factors between those whose sleep duration of the night before school days were ≤7 hours or >7 hours in each non-school day catch-up sleep category. Significant difference on Dunnett's multiple comparison test was expressed as follows; *: $P < 0.05$; **: $P < 0.01$.

with nSDCUS > 2 hours. Pupils with negative nSDCUS showed a significant later bedtime and a shorter sleep duration before non-school day in both the SSG and LSG. A significant shorter average sleep duration and longer screen time of pupils with negative nSDCUS were obtained only in the SSG. In the LSG, pupils with negative nSDCUS showed a significant male predominancy, later waking time on school days, longer physical and after-school activities. In both the SSG and LSG, pupils with the longest nSDCUS revealed a significant female dominancy, later bedtime before school days and waking time on non-school day, and a longer sleep duration before non-school day, average sleep duration, social jetlag, and screen time. In the SSG, pupils with the longest nSDCUS showed a significant later bedtime before non-school day and waking time on school days, and a shorter physical activity. Pupils with nSDCUS > 2 hours in the LSG showed a significantly higher grade, more sleepiness and breakfast skipping, and poorer academic performance and defecation habit.

Significant regression formula for a dependent variable of nSDCUS was obtained for whole dataset (adjusted R^2 = 0.21, P < 0.001). Female gender, decreased sleep duration before school days, standardized BMI, after-school activity and physical activity were significantly associated with increased nSDCUS (Table 2). On this analysis, among the explanatory variables, sleep duration of the night before school days showed the highest significant standardized regression coefficient value. Significant regression formulae for a dependent variable of nSDCUS were also obtained for both the SSG and LSG as follows: SSG (adjusted R^2 = 0.08, P < 0.001), and LSG (adjusted R^2 = 0.07, P < 0.001). Decreased physical and after-school activities were significantly associated with an increase in nSDCUS in both groups (Table 3). Among pupils in the LSG, a decrease in screen time, male gender, and an increase in the standardized BMI were significantly associated with decreased nSDCUS (Table 3).

4. Discussion

This study revealed that the percentage of pupils in negative nSDCUS category was 6.6%, whereas that in nSDCUS > 2 hours was 14.4%, respectively. Both of these values were not too low to be able to neglect. The nSDCUS is considered to reflect sleep debt [4] [5] [6], and problems in pupils with a long nSDCUS have long been concerned. Lee *et al.* [17] described pupils with negative nSDCUS, however, the study did not count the number of pupils with negative CUS and, instead, calculated the CUS ratio (calculated as the average weekend sleep duration (hours)/average weekday sleep duration (hours)). A CUS ratio < 1.00 could be considered equal to a negative nSDCUS in the current study. According to

Table 2. Independent predictors of non-school day catch-up sleep investigated in the whole dataset determined by multiple regression analysis.

Variables	Regression coefficient				β	P
	95% CI					
Constant	4.49	3.91	to	5.08	4.49	<0.001
Grade	−0.03	−0.05	to	0.00	−0.04	0.071
Gender (male: 1; female: 2)	0.24	0.15	to	0.33	0.09	<0.001
School day sleep duration	−0.44	−0.49	to	−0.39	−0.42	<0.001
Standardized BMI	−0.06	−0.10	to	−0.01	−0.04	0.011
Self-reported academic performance	0.02	−0.04	to	0.07	0.01	0.543
Sleepiness during class	0.02	−0.04	to	0.08	0.01	0.522
Breakfast taking	0.01	−0.07	to	0.09	0.01	0.768
Defecation frequency	−0.03	−0.08	to	0.02	−0.02	0.233
After-school activity (hrs./week)	−0.02	−0.02	to	−0.01	−0.10	<0.001
Physical activity (days/week)	−0.07	−0.09	to	−0.06	−0.16	<0.001
Average screen time a day (hrs)	0.05	0.00	to	0.11	0.03	0.070

BMI: body mass index; CI: confidence interval; β: standardized regression coefficient.

Table 3. Independent predictors of non-school day catch-up sleep investigated separately in both shorter and longer school day sleep duration determined by multiple regression analysis.

School day sleep duration	Variables	Regression coefficient				β	P
		95% CI					
More than 7 hours	Constant	−0.06	−0.42	to	0.30	−0.06	0.746
	Grade	0.02	−0.02	to	0.05	0.02	0.396
	Gender (male: 1; female: 2)	0.33	0.22	to	0.45	0.15	<0.001
	Standardized BMI	−0.06	−0.11	to	−0.01	−0.05	0.030
	Self-reported academic performance	0.00	−0.07	to	0.07	0.00	0.952
	Sleepiness during class	0.06	−0.02	to	0.14	0.04	0.171
	Breakfast taking	0.09	−0.03	to	0.22	0.04	0.143
	Defecation frequency	0.00	−0.06	to	0.06	0.00	0.971
	After-school activity (hrs./week)	−0.02	−0.03	to	−0.01	−0.09	<0.001
	Physical activity (days/week)	−0.03	−0.05	to	−0.01	−0.09	0.001
	Average screen time a day (hrs)	0.11	0.04	to	0.19	0.08	0.004
7 hours or less	Constant	1.58	0.97	to	2.19	1.58	<0.001
	Grade	0.00	−0.04	to	0.05	0.00	0.883
	Gender (male: 1; female: 2)	0.15	−0.01	to	0.32	0.05	0.064
	Standardized BMI	−0.03	−0.10	to	0.05	−0.02	0.492
	Self-reported academic performance	0.05	−0.05	to	0.14	0.03	0.348
	Sleepiness during class	0.04	−0.06	to	0.14	0.02	0.409
	Breakfast taking	−0.03	−0.15	to	0.09	−0.01	0.641
	Defecation frequency	−0.05	−0.13	to	0.04	−0.03	0.308
	After-school activity (hrs./week)	−0.01	−0.02	to	0.00	−0.07	0.012
	Physical activity (days/week)	−0.12	−0.14	to	−0.09	−0.26	<0.001
	Average screen time a day (hrs)	0.06	−0.03	to	0.14	0.04	0.192

BMI: body mass index; CI: confidence interval; β: standardized regression coefficient.

Lee *et al.* [17], the rate of pupils with CUS ratio < 1.00 was 25.2%, which is higher than the present result of 6.6% for negative nSDCUS pupils. To identify the reason for this difference, we should determine the characteristics of pupils with negative nSDCUS. According to DMCT, the negative nSDCUS group in the present study showed a later bedtime and shorter sleep duration on the night before non-school days. Unfavorable sleep status on the night before non-school days may be associated with negative nSDCUS pupils, suggesting that sleep status of pupils on the night before non-school days in Japan may not be worse than that in South Korea.

Furthermore, Lee *et al.* [17] reported a significant association of depressive

symptoms and suicidal ideation with pupils whose CUS ratio < 1.00. Then, it is assumed that both long nSDCUS and those with a negative nSDCUS need attention among pupils. Indeed, in my personal experience, several male students had to join away-from-home matches almost every weekend, so they lacked sleep due to a combination of school obligations and athletic practices [22]. Most likely, these pupils belong to the negative nSDCUS category. Indeed, pupils with a negative nSDCUS values showed the shortest averaged sleep duration among the five nSDCUS categories in both the LSG and SSG, and the averaged value in the SSG was significantly shorter than that in the reference category.

Furthermore, Lee *et al.* [17] reported that pupils who had both a weekday sleep duration < 5 hours and a CUS ratio < 1.00 demonstrated the highest odds for depressive symptoms and suicidal ideation. The authors accordingly interpreted this result as being attributable to an absolute lack of sleep, and concluded that not only CUS but also weekday sleep duration should be considered in order to improve adolescents' mental health. According to Lv *et al.* [18], children with a <9-hour weekday sleep duration had poorer executive function scores, and their CUS values showed no correlation with scores. Lv *et al.* [18] concluded that CUS could not compensate for the executive function deficits related to short weekday sleep duration Interestingly, they also found that children with CUS > 1 h our was associated with poor executive function even if they had >9 hours weekday sleep duration. In order to achieve adequate execute function, they recommended avoiding a 1-hour CUS [18]. These reports suggest that CUS value should not be discussed alone but should be considered in association with the weekday sleep duration. Tonetti *et al.* [19] investigated the association between CUS and subjective well-being in both shorter (<7 hours) and longer (≥7 hours) sleep-duration groups among 504 Italian pupils aged 14 - 18 years, and found a significantly lower well-being level in pupils with ≥2-hour CUS than those with 0 or <1-hour CUS only in the shorter sleep-duration group.

In the present study, similar to Tonetti *et al.* [19] but different from Lv *et al.* [18], a percentage of pupils with nSDCUS > 2 hours was higher in the SSG (25.2%) than in the LSG (5.7%). The current MRA demonstrated longer nSDCUS pupils spent significantly shorter time taking part in physical and after-school activities in both the SSG and LSG. However, the difference in the significant association with nSDCUS between these two groups was determined in gender, screen time, and standardized BMI. The shorter nSDCUS in the LSG was associated with male gender, shorter screen time, and higher standardized BMI, in addition to a longer time being engaged in physical and after-school activities. These findings are compatible for the hypothesis [17] [18] [19] that weekday sleep duration contributes differently to nSDCUS evaluation.

Interestingly, predominantly male participants with longer physical and after-school activities, and shorter screen time in shorter nSDCUS with the LSG were similar features as those seen in pupils with negative SJL [22], who were predominantly male, spent longer durations in physical and after-school activities, had less screen time, and shorter sleep duration on nights before non-school days.

Indeed, the shortest nSDCUS category (e.g. negative nSDCUS) with LGS showed the shortest SJL value of 0.3 (**Table 1**), and this category included 38 pupils with negative SJL among a total of 114 negative-SJL pupils [22].

Although the current DMCT demonstrated that the pupils with nSDCUS > 2 hours showed a significantly poorer academic performance only in the LSG, the present MRA failed to show significant associations between nSDCUS and academic performance as described by Kuula *et al.* [8]. Not a short sleep duration [21] but a higher sleepiness [23] is found to be associated with poor academic performance. It could be assumed that pupils with long optimal sleep duration are tended to be suffering from sleepiness, although sleepiness in the current study showed no significant difference on both DMCT and MRA. The difference in the participants' optimal sleep duration might produce inconsistent results among various studies on academic performance [7] [8] [9].

The present DMCT failed to show a significant difference of standardized BMI value of each nSDCUS category in comparison to the reference category, however, the current MRA demonstrated the significant association between the shorter nSDCUS and higher standardized BMI in the LSG. An increased BMI associated with short sleep duration [3], and the shortest average sleep duration of 6.0 hours was seen in the negative-nSDCUS category in the SSG (**Table 1**). Thus, a significantly increased BMI was anticipated in regard to the association of the shorter nSDCUS category of the SSG. However, this expectation was not confirmed, which might be attributable to the large interindividual variations for sleep need or optimal sleep duration [26]. The optimal sleep duration of pupils in the SSG might be shorter than those in the LSG. Therefore, further studies are needed to confirm this hypothesis.

With regard to screen time, the current DMCT demonstrated that pupils in the longest nSDCUS category both in the SSG and LSG groups had significantly longer screen times as compared with a reference category. This result was consistent with the findings reported previously by Mireku *et al.* [15]. In addition, in the SSG, negative nSDCUS pupils showed a significantly higher screen time. However, the present MRA revealed a significant positive association of screen time with nSDCUS only in the LSG. To the best of my knowledge, no similar description has been found in literatures. Further studies are needed to confirm this finding.

There were some limitations in the current study. First, this study used a cross-sectional design and was unable to identify a causal relationship. Second, the questionnaire was not standardized or validated, and the response choices in the questionnaire were rather subjective, although the assessment survey was based on a questionnaire used in a national survey [27]. Third, the present study did not include demographic factors such as family composition, socio-economic status, and parents' educational background.

Despite the above limitations, the current study succeeded in confirming the hypothesis that sleep duration on the night before school days contributed diffe-

rently to nSDCUS evaluation. This finding might also be associated with optimal sleep duration similar to academic performance and BMI. The notion of optimal sleep duration might be indispensable issue to be discussed for future nSDCUS studies. In addition it was found that attention should be paid on pupils with not only a long nSDCUS value but also those with a negative value.

5. Conclusion

Sleep duration before school days contributed differently to the nSDCUS evaluation. Since nSDCUS was found to be a function of sleep duration on the night before school days, the notion of optimal sleep duration must be taken into consideration for future studies on nSDCUS.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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