Lower physical activity is associated with daytime sleepiness in children aged 9-12 years.

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博 士 論 文

Lower physical activity is associated with daytime sleepiness in children aged 9-12 years.

（9-12 歳の児童における身体活動と日中の眠気の関連）

令和２年１月１６日

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Abstract

This study clarified the prevalence of daytime sleepiness in fourth-, fifth-, and sixth-grade children and examined the association between physical activity (PA) and daytime sleepiness in children aged 9–12 years. This cross-sectional study included 314 children (mean age+standard deviation: 10.5 ± 1.0 years; male: 52.9%) enrolled in two public elementary schools in Kobe, Japan. PA was assessed using the Physical Activity Questionnaire for Older Children. The outcome was self-reported daytime sleepiness. The prevalence of daytime sleepiness in fourth-, fifth-, and sixth-grade children were 10.8%, 25.2%, and 28.6%, respectively. In univariate analysis, subjects with reported daytime sleepiness had lower PA levels than those without daytime sleepiness (odds ratio (OR) = .67; 95% confidence interval (CI) = .47–.95). Multiple logistic regression analysis demonstrated that lower PA was significantly associated with daytime sleepiness after adjusting for multiple confounders (OR = .54; 95% CI = .37–.81). The prevalence of daytime sleepiness in fifth and sixth grades was higher than fourth grade. Furthermore, this study clarified the significant association between PA and daytime sleepiness and suggested that PA could be one of the factors to prevent daytime sleepiness in children aged 9–12 years.

Keywords

Habitual physical activity, prevalence, school-aged children, sleepiness

Announcement

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Introduction

Insufficient sleep impairs physical and psychological development, emotional well-being, and overall health in older children (9–12 years old). Recently, increasing attention is being devoted to daytime sleepiness. The prevalence of daytime sleepiness in children aged 9–12 years is reported to range from 13.0% to 22.0% (Gustafsson et al., 2016; Khan et al., 2015), which is equivalent to or greater than that in adults and the elderly (Joo et al., 2009; McClain et al., 2014). Daytime sleepiness is linked to a lack of concentration, learning disabilities, and poor academic performance (Beebe et al., 2010; Li et al., 2013). Further, a recent enumerative review revealed that sleep characteristics including daytime sleepiness may increase cardiovascular risk in children and adolescents (Matthews and Pantesco, 2016). Thus, strategies for preventing and correcting daytime sleepiness in children are necessary.

Although the causes of daytime sleepiness in children have not been fully clarified, daytime activities including physical activity (PA) are reported to be associated with daytime sleepiness (Gaina et al., 2007; Khan et al., 2015). Engaging in regular PA during the daytime is recommended by the National Sleep Foundation to improve sleep quantity and quality, although the results of studies investigating this association are inconsistent (Ekstedt et al., 2013; Stone et al., 2013). In addition, a lack of epidemiological evidence of the association of PA with daytime sleepiness remains. Besides PA, age (Janssen et al., 2017), gender (Janssen et al., 2017), body status including height and body mass (Calhoun et al., 2011), socioeconomic status (Jarrin et al., 2014), and disturbed or inadequate sleep are reportedly associated with daytime sleepiness (Hirshkowitz et al., 2015; Kallambellaand Hussain, 2015). In line with the increasing availability of small electronic devices (EDs), some studies recently reported significant associations of bedtime habits (use of small EDs during the night or after lights-out) (Falbe et al., 2015) and the bedroom environment (presence or absence of TV in the bedroom) (Buxton et al., 2015) with daytime sleepiness. PA and these variables associated with bedtime and the bedroom environment are considered modifiable factors that influence daytime sleepiness. Although the association between PA and daytime sleepiness in adults and the elderly has been studied relatively well (Chasens et al., 2011; McClain et al., 2014; Riegel et al., 2012), studies focused on children of multiple grades from fourth to sixth

grades are limited.

Given that higher grade children appear to have shorter sleep durations (Galland et al., 2012), it is hypothesized that the prevalence of daytime sleepiness increases in higher grade. In the present study, we aimed to (1) clarify the prevalence of daytime sleepiness in various grade levels and (2) examine the association between PA and daytime sleepiness in children aged 9–12 years. Identifying an association between PA and daytime sleepiness could provide the basis for successful strategies to prevent and reduce daytime sleepiness.

Methods

Participants and setting

We recruited fourth, fifth, and sixth graders from two public elementary schools in Kobe, Japan, in September and October 2016. Children who did not complete a self-administrated questionnaire, and those who answered 'Yes' to question no. 10 (Were you sick last week, or did anything prevent you from doing your normal physical activities?) of the Japanese version of the Physical Activity Questionnaire for Older Children (PAQ-C), were excluded (Crocker et al., 1997). The study protocol was approved by the Research Ethics Committee of the Kobe University Graduate School of Health Sciences. We explained the study protocol to principals and teachers at the two schools who agreed to participate in the study. Informed assent and consent were obtained from all participating children and their guardians.

Measurements

Daytime sleepiness. The presence or absence of daytime sleepiness was operationally assigned by asking the following question: 'Are you sleepy during the daytime?' Subjects indicated how often they felt sleepy (always, often, sometimes, and never) (Saarenpaa-Heikkila et al., 2000). The presence of daytime sleepiness (daytime sleepiness+) was indicated by an answer of always or often, and those who answered sometimes or never were assigned to the daytime sleepiness− group (Saarenpaa-Heikkila et al., 2000).

Physical activity. PA was assessed using the Japanese version of PAQ-C which had

acceptable reliability and validity (In this study: Cronbach's alpha = .81) (Isa et al., 2019). The PAQ-C is a self-reported seven-day recall questionnaire for children aged 8–14 years (Crocker et al., 1997; Kowalski et al., 1997). The PAQ-C consists of nine computable items scored using a 1–5 Likert-type scale, with higher scores indicating higher PA levels. The individual PAQ-C score was calculated as the mean score of the nine items. Thus, the individual PAQ-C score ranged between 1.00 (lowest activity level) and 5.00 (highest activity level) and was used as a continuous variable.

Other variables. Demographic data including age, grade, and gender were obtained from the questionnaire. We assessed height (cm) and body mass (kg) with stadiometer (Muratec-KDS, Kyoto, Japan) and body mass scale (Tanita, Tokyo, Japan), respectively, and body mass index (BMI) (kg/m^2) was calculated as body mass in kilograms divided by height in meter squared. Further, we examined potential confounders for daytime sleepiness, including sleep duration, small EDs use after lights-out, and the use of certain EDs during the daytime.

We assessed awake time and bedtime on each day of past one week by questionnaire, using modified and extracted items from the Pittsburgh Sleep Quality Index (Matricciani, 2013). Children were asked: (1) When have you usually gone to bed on weekdays (Monday to Friday) and weekends (Saturday to Sunday) at night? and (2) When have you usually awaken on weekdays and weekends at morning? Then, we estimated the mean sleep duration by calculating based on the sum of five weekdays and two weekend days divided by seven (Tsai et al., 2005). The National Sleep Foundation recommends appropriate sleep duration for school-aged children (6–13 years old) of 9–11 hours (National Sleep Foundation, 2015). Therefore, children with sleep durations of at least nine hours comprised the adequate sleep duration group, and those with shorter sleep durations were assigned to the inadequate sleep duration group.

We assessed the frequency of use of small EDs, such as portable game machines (e.g. Nintendo DS and PlayStation Portable) and mobile phones after lights-out (Falbe et al., 2015). Subjects were categorized into the usage (≥1day/week) and nonusage groups (none) (Falbe et al., 2015).

We assessed the number of hours children used EDs, including TVs, video game systems (e.g. PlayStation, Xbox, GameCube, Nintendo DS, and PlayStation Portable), and mobile phones during the daytime. Subjects indicated the number of hours of EDs use as 0 minutes, 30 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, or ≥7 hours/day (Schmitz et al., 2004). Time spent watching TV was categorized as <2 hours/day or ≥2 hours/day (Schmitz et al., 2004). Time spent playing games and using mobile telephones was categorized as <30 minutes/day or ≥30 minutes/day (Kondo et al., 2012).

Statistical analyses

To compare the differences in characteristics between grades, analysis of variance was used for continuous variables and Kruskal-Wallis rank test was used for categorical variables. Subsequently, the Bonferroni test and Dunn's pairwise comparison as a post hoc test were performed. Differences between the characteristics of subjects within a grade were analyzed using the Cochran-Armitage trend test for proportions and the linear trend test for continuous variables. In univariate and multivariate analysis, we performed single and multiple logistic regression analysis to examine the association between PA and daytime sleepiness according to the students' grade level, sleep duration, and small EDs use after lights-out, which are known to be associated with daytime sleepiness (Carter et al., 2016; Urschitz et al., 2013).

Statistical analyses were performed using STATA software version 14.0 (StataCorp, College Station, TX, USA). The level of significance for all statistical analyses was set at $p \leq .05$.

Results

In total, 350 children were enrolled in this study (fourth graders: n = 114 [32.6%]; fifth graders: n = 117 [33.4%]; and sixth graders: n = 119 [34.0%]). Of these participants, we excluded 10 children who did not complete the questionnaire and 26 children who answered that they could not regularly engage in PA during the past week because of sickness, injury, or other reasons. Finally, we included 314 children in the analyses (mean age ± standard deviation: 10.5 ± 1.0 years; male: 52.9%).

Of the 314 children, 68 (21.7%) exhibited daytime sleepiness. The prevalence of daytime sleepiness in fourth, fifth, and sixth graders were 10.8%, 25.2%, and 28.6%, respectively (Figure 1). A linear trend test significantly demonstrated that the prevalence of daytime sleepiness increased with increasing grade level ($p < .01$).

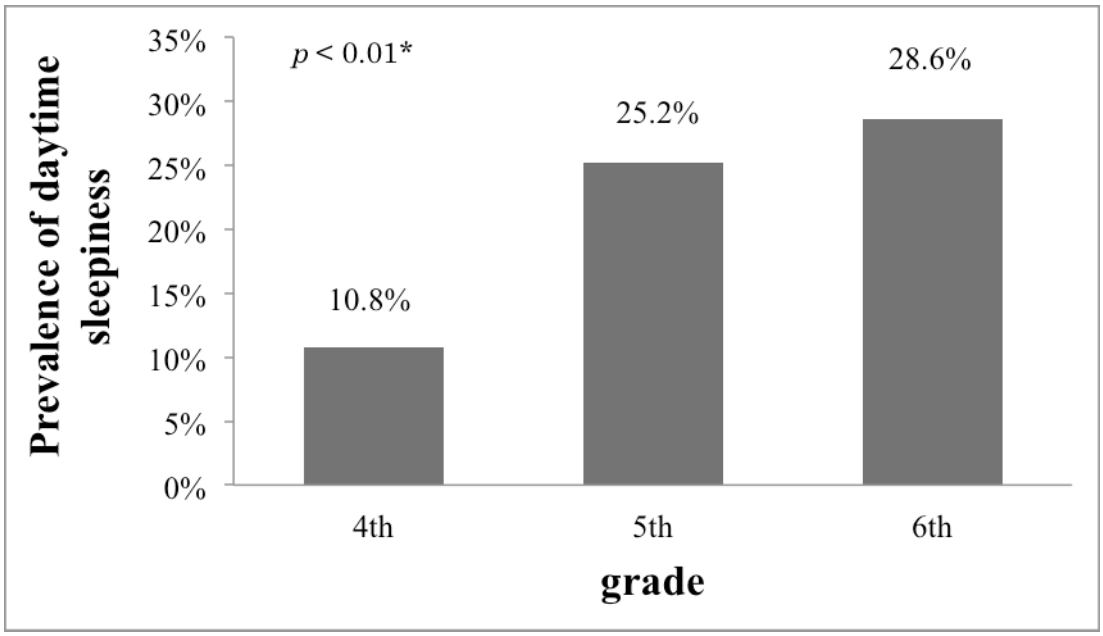

Figure 1. Prevalence of daytime sleepiness in fourth-, fifth-, and sixth-grade children.

Table 1 presents differences in the characteristics of subjects between grades. The prevalence of daytime sleepiness in fifth and sixth graders was significantly higher than those in fourth graders (vs. fifth graders, $p < .01$ and vs. sixth graders, $p < .01$). BMI was significantly higher in fifth and sixth graders than in fourth graders (vs. fifth graders, $p = .02$ and vs. sixth graders, $p < .01$). PA was significantly higher in fifth graders than in fourth (vs. fifth graders, $p < .01$) and sixth graders (vs. fifth graders, $p < .01$). The sixth graders were more likely to use small EDs after lights-out (vs. fourth graders, $p < .01$ and vs. fifth graders, $p = .01$) and have inadequate sleep durations (vs. fourth graders, $p < .01$ and vs. fifth graders, $p = .01$) compared with fourth and fifth graders. Furthermore, the number of children who watched TV for ≥2 hours was significantly higher in sixth graders than in fourth graders (vs. sixth graders, $p < .01$). There were no differences in gender or the duration playing video games or using mobile telephones during the daytime between graders.

Table 1. Characteristics of subjects by grade

Variable	Fourth grade (N = 102)	Fifth grade (N = 107)	Sixth grade (N = 105)	*p* Value	*p* Value for trend
Male, n (%)	49 (48.0)	62 (57.9)	55 (52.4)	0.36	*n.a.*
Daytime sleepiness, n (%)	11 (10.8)	27 (25.2)	30 (28.6)	<0.01[a,b]	<0.01
BMI, kg/m^2	16.7 ±2.3	17.7 ±2.6	18.3 ±3.2	<0.01[a,b]	<0.01
Physical activity, PAQ-C score	2.51±0.73	2.98±0.86	2.55±0.73	<0.01[a,c]	0.82
Use of Small EDs after lights-out, n (%)	17 (16.7)	23 (21.5)	37 (35.2)	<0.01[b,c]	<0.01
Sleep duration					
Mean sleep duration, min	542±54	534±54	517±66	0.01[b]	<0.01
Sleep duration (<9 h), n (%)	43 (42.2)	50 (46.7)	65 (61.9)	0.01[b,c]	<0.01
TV time (≥2 h), n (%)	52 (51.0)	66 (61.7)	71 (67.6)	0.047[c]	0.01
Video game time (≥30 min), n (%)	73 (71.6)	66 (61.7)	69 (65.7)	0.32	0.38
Mobile telephone time (≥30 min), n (%)	63 (61.8)	69 (64.5)	74 (70.5)	0.40	0.19

Unless otherwise noted, data are presented as the mean ± standard deviation. *p* Value shows the results of analysis of variance for continuous variables and Kruskal-Wallis rank test for categorical variables. The Bonfferoni test and Dunn's Pairwise Comparison test were used as post hoc tests. *p* Value for trend shows the results of the Cochran-Armitage trend test for proportions and the linear trend test for continuous variables. BMI: body mass index; PAC-Q: Physical Activity Questionnaire for Older Children; EDs: electronic devices; SD: standard deviation; ANOVA: analysis of variance.

[a] *P* <0.05: fourth versus fifth grade; [b] *P* <0.05: fourth versus sixth grade; [c] *P* <0.05 fifth versus sixth grade.

Table 2. Univariate and multivariate logistic regression analysis of factors associated with daytime sleepiness

	Univariate		Multivariate	
Variable	OR	(95% CI)	OR	(95% CI)
Physical activity	0.67	(0.47–0.95)	0.54	(0.37–0.81)
Grade (ref. Fourth)				
Fifth	—	—	3.56	(1.58–8.02)
Sixth	—	—	2.61	(1.18–5.74)
Use of small EDs after lights out (ref. No)	—	—	2.77	(1.50–5.12)
Sleep duration <9 h (ref. ≥9 h)	—	—	1.99	(1.10–3.60)

Note: The analysis was adjusted for grade, small EDs use after lights-out, and sleep duration. EDs, electronic devices; OR, odds ratio; CI, confidence interval.

In the multivariate analysis, children with lower PA were about .54 times ($p < .01$) more likely to have daytime sleepiness compared to children with higher PA after adjustment for grade, sleep duration, and small EDs use after lights-out (Table 2). Children in fifth graders were about 3.56 times ($p < .01$) and children in sixth grade were about 2.61 times ($p = .02$) more likely to have daytime sleepiness compared to children in fourth grade. Children with small EDs use after lights-out were about 2.77 times ($p < .01$) more likely to have daytime sleepiness compared to children without small EDs use after lights-out. Children with inadequate sleep duration were about 1.99 times ($p = .02$) more likely to have daytime sleepiness compared to children with adequate sleep duration.

Discussion

This study investigated the prevalence of daytime sleepiness according to grade level and examined the association of PA in children aged 9–12 years. According to our results, the prevalence of daytime sleepiness in fifth and sixth graders was higher than fourth graders. Further, this study indicated the significant association between lower PA levels and daytime sleepiness after adjusting for confounders.

In the present study, the prevalence of daytime sleepiness was 21.7%, in-line with

previous findings in children aged 10–12 years (Gustafsson et al., 2016; Khan et al., 2015). In contrast, according to a large study of Japanese adolescence in seventh graders, the prevalence of daytime sleepiness was reported to be 72.8% (Gaina et al., 2007), indicating that there was a deviation from the results obtained in the present study. However, in another study on Japanese adolescents between the seventh and twelfth graders, the prevalence was reported to be 39.1% in males (increasing from 25.2% in 7th graders to 44.7% in 12th graders) and 46.0% in females (increasing from 31.1% in 7th graders to 52.2% in 12th graders) (Munezawa et al., 2011), indicating that higher-grade children exhibited higher prevalence of daytime sleepiness. In general, compared with children in lower grades, higher-grade children appeared to sleep less and use small EDs more frequently at night and after lights-out (Brambilla et al., 2017). The findings of the present study, which showed that higher-grade children had a shorter sleep duration and higher use of small EDs after lights-out, supported this previous study. Therefore, these factors may explain the association between grade level and daytime sleepiness.

The present study revealed that PA was significantly associated with daytime sleepiness after adjusting for multiple confounding factors. To our knowledge, only one previous study investigated the association between PA and daytime sleepiness in fifth graders (Khan et al., 2015). They reported a significant association between PA and daytime sleepiness after adjusting for gender, household income, parental education, place of residence, sleep duration, typical bedtime on weekdays and the weekend, and the presence of snoring in fifth-grade Canadian children (Khan et al., 2015). The findings of the present study supported those of this previous study. Furthermore, the present study demonstrated that sixth graders showed significantly shorter sleep duration and higher use of small EDs after lights-out than fourth and fifth graders, indicating lifestyle changes by grade. The use of small EDs after lights-out has received increased attention owing to its potential influence on daytime sleepiness (Carter et al., 2016; Felbe et al., 2015). The present study, including multiple grades (fourth to sixth grade), highlighted the significant link between PA and daytime sleepiness independent of grade, use of small EDs after lights-out, and sleep duration.

Although the mechanism underlying the association between PA and daytime sleepiness is poorly understood, there is substantial evidence showing the association between PA and sleep. In a cross-sectional study, Singh et al. (2008) reported a significant association between the mean number of days of physical inactivity and inadequate sleep in the past week. Liu et al. (2000) also reported that the absence of habitual PA in the past year was significantly associated with an increased risk of insomnia in children. Furthermore, according to a study examining the day-to-day association between objective measures of PA and sleep quantity and quality, PA significantly affected sleep quality, although sleep quantity and quality did not affect PA (Ekstedt et al., 2013). These previous studies appear to support the results of the present study that PA is associated with daytime sleepiness. By contrast, there is a possibility of reverse causality in this association. The weekday–weekend regularity of sleep was reported to have impact on PA in a study examining the association between sleep throughout the week and PA in children (Stone et al., 2013). To date, although the causality in this association between PA and daytime sleepiness remains to be elucidated, the present study hypothesized that PA is closely associated with daytime sleepiness in children aged 9–12 years. In this connection, circadian rhythms have been identified as a possible cause. According to circadian rhythms, PA leads to sleepiness during the night (Dahl, 2004). Based on these studies, it is possible that circadian rhythms influence the association between PA and daytime sleepiness. Further research in consideration of circadian rhythms is needed to investigate this association in detail.

The study had several limitations. First, because of the cross-sectional nature of the study, a causal relationship could not be revealed. Further longitudinal studies are needed. Second, the study assessed PA and sleep duration using a self-reported questionnaire. In cases using a self-reported questionnaire for children, findings may be affected by recall bias (Nixon et al., 2008). However, to minimize the potential bias, a valid and reliable questionnaire was used to assess PA and sleep duration in the present study. In the future, objectivemeasurements of PA, including the use of an accelerometer, are recommended for precise evaluation. In the present study, the single-item assessment was used, which has been used in previous studies in Japan (Gaina et al., 2005; 2007). In Japan, the Japanese version of

the Pediatric Daytime Sleepiness Scale is used, in which an instrument includes the elements that are affected by mood and home environment measures, which are different aspects of daytime sleepiness (Gaina et al., 2007). Finally, the length of the school day and the volume of homework appear to be increased with grade (Ishii et al., 2017), and these factors may affect their PA and daytime sleepiness. However, these factors were not assessed in the present study.

Conclusion

In conclusion, the prevalence of daytime sleepiness increased in higher-grade children in fourth to sixth grades. Furthermore, lower PA was significantly associated with daytime sleepiness after adjusting for multiple confounding variables, suggesting that PA may be one of the factors associated with daytime sleepiness in children aged 9–12 years. As there are limited reports on the association between PA and daytime sleepiness among children aged 9–12 years, further investigations are required to confirm the findings of the present study.

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