

Association between sleep disorders and academic performance: Finding of health survey and academic performance in the Bio-Bio province 2018

Asociación entre problemas de sueño y rendimiento escolar: Resultados de la encuesta de salud y rendimiento escolar de la provincia del Biobío 2018

Mario Henríquez-Beltrán^a, Rafael Zapata-Lamana^b, Jessica Ibarra-Mora^c,
Sonia Sepúlveda-Martin^d, Laura Martínez^d, Igor Cigarroa^a

^aEscuela de Kinesiología, Facultad de Salud, Universidad Santo Tomás. Los Ángeles, Chile.

^bEscuela de Educación, Universidad de Concepción. Los Ángeles, Chile.

^cDepartamento de Educación Física, Deporte y Recreación, Universidad Metropolitana de Ciencias de la Educación. Santiago, Chile.

^dDepartamento de Ciencias Clínicas y Preclínicas, Facultad de Medicina, Universidad Católica de la Santísima Concepción. Concepción, Chile.

Received: March 15, 2021; Approved: October 16, 2021

What do we know about the subject matter of this study?

Sleep is currently considered a variable that may be associated with cognitive performance in children and adolescents. However, in Latin American countries such as Chile, sleep habits are still considered an emerging study area with little evidence on the relationship with school performance.

What does this study contribute to what is already known?

To date, this study is the most updated local evidence that shows a high prevalence of sleep routine problems and a relationship between sleep problems and lower school performance and poorer cognitive function perception in schoolchildren in public schools.

Abstract

Objective: To analyze the association between sleep disorders, behaviors associated with cognition, and academic performance in elementary school students. **Subjects and Method:** Analytical and cross-sectional research including 733 students from 5th and 8th grades from public schools participating in the study "Health survey and academic performance in the Bio-Bio Province 2018". The sleep disorders were reported through a sleep self-report questionnaire, and the academic performance was measured through the grade point average (GPA) in subjects language, mathematics, physical education, general point averages, and perception of cognitive functions in a school context. **Results:** 81.9% of the schoolchildren indicated problems with bedtime routines. The students with sleep disorders of both sexes presented higher memory problems, are slower in resolving math pro-

Keywords:

Sleep Disorders;
Academic Performance;
Cognition;
Chile;
School Performance

blems, have higher difficulties to maintain attention in classes, have more problems solving complex tasks, and more nervousness during a test than the student classified as not having sleep disorders. Additionally, the students with sleep disorders presented lower grades in their GPA and the subjects mathematics, language, and physical education than those students without sleep disorders. **Conclusion:** A high prevalence of bedtime routine problems was detected as well as an association between sleep disorders and lower academic performance together with a worse perception of cognitive functions in schoolchildren. Implementing health promotion strategies, focused on sleep hygiene in educational centers could improve academic performance.

Introduction

Academic performance in children and adolescents has been related to their habits and lifestyles. Therefore, a positive academic performance has been associated with a healthy diet, physical activity, and sufficient sleep according to age¹. However, the health habits of Chilean schoolchildren are far from adequate. Evidence indicates that schoolchildren with high levels of obesity, low levels of physical activity, and poor physical condition have lower school performance²⁻⁴.

Regarding sleep, recent studies have shown that children and adolescents have changed their sleep patterns, demonstrating that, in the last 20 years, adolescents who sleep more than 7 hours per night and who report an adequate nighttime sleep have decreased considerably⁵. In 2005, a South Korean study reported one of the most important decreases in sleep hours, where the average sleep was 4.9 hours per night⁶. In Chile, the National Health Survey showed that 64.8% of young people reported sleep disorders such as nighttime snoring and parasomnias⁷. Specifically, 11.8% of high school students reported having poor sleep quality⁷. According to international evidence, our country is among the eight countries where schoolchildren and adolescents suffer the most sleep problems (63% of students in 4th grade and 74% in 8th grade)⁸. The evidence suggests that the cause of these problems are psychosocial pressures and the decrease in parental control over their children's bedtimes⁹, and the increase in technology and its growing ease of access have also had a negative influence, as has been evident in the last decade^{10,11}.

The increase in sleep problems in children and adolescents has generated concern in the health and education sphere, specifically in school performance, since getting enough sleep is crucial for optimal cognitive and physiological development¹². A recent systematic review showed that different forms of sleep deprivation are detrimental to the emotional, behavioral, and cognitive functions of students¹³. Higher-order cognitive skills, such as performance and behavior, are sensitive when there is a reduction in both the quantity

and quality of sleep, negatively affecting academic performance^{14,15}.

Physiologically, the association between sleep problems and cognitive and academic performance could be caused by an alteration in the rapid eye movement (REM) and non-rapid eye movement (non-REM) phases. The REM phase is characterized by low-amplitude, high-frequency waves on an electroencephalograph (EEG)^{16,17} and has been linked to learning and memory¹⁸. On the other hand, the non-REM phase presents high-amplitude, low-frequency EEG waves, and is characterized by decreased muscle tone and slow eye movement^{16,17}. Also, it has been related to the regeneration of musculoskeletal tissue, the strengthening of the immune system¹⁷, and the consolidation of declarative memory¹⁹.

In recent years, sleep has been considered as a relevant variable associated with higher cognitive functions¹³. However, in Latin American countries such as Chile, sleep is still considered an emerging area and there is little evidence on how sleep habits can be related to school performance. Its emotional, behavioral, and cognitive implications have been little explored in the school population, which is paradoxical, considering the high prevalence of sleep problems found in Chilean children and adolescents⁸. According to the existing evidence, this is the first study that analyzes the association between sleep disorders and academic performance in Chilean schoolchildren. The objective of this study was to analyze the association between sleep problems and academic performance in schoolchildren from fifth to eighth grade from public schools in the province of Biobío, Chile.

Subjects and Method

Design and participants

Analytical, cross-sectional study using data from the *Health and School Performance Survey 2018* of the province of Biobío. All schoolchildren from fifth to eighth grade from all public schools of a commune in the province of Biobío, Chile ($n = 3,857$) were invi-

ted to participate. A probabilistic and stratified sample with communal representativeness of 797 Chilean schoolchildren (12 ± 1.3 years) who completed all the measurements were included, after signing the consent of the parents/legal guardian. 64 schoolchildren were excluded due to non-attendance the day of the measurements and not signing the informed consent. The sample finally consisted of 733 schoolchildren (53.9% males; 12 ± 1.3 years). For the sample calculation, 5% error and 95% confidence were considered.

Procedure

A partnership was established between the inter-university research team and the Municipal Administration and Education Department. Once approval from the ethics committee and municipal authorization were obtained, the design and selection of variables were carried out jointly with the directors and teachers from public schools. Subsequently, teachers were trained to apply the instruments in order to reduce inter-evaluator bias. Data collection was carried out in all educational establishments, on the same day and during the same class hours. Families, directors, and teachers were informed about the purpose of the study and agreed to collaborate in it. The project was approved by the Ethics Committee of the Vice-Rectoría of Research and Development of the Universidad de Concepción, Chile.

School performance

Schoolchildren's performance was assessed considering the grade point average and perception of cognitive functions in the school context.

- a. *Grade Point Average:* The grades for language arts, mathematics, physical education, and the grade point average for the first academic semester were reported. The averages range from 1.0 to 7.0, where 4.0 is the passing grade. No differences in academic standards were considered since all the schools were public and therefore follow the same curricular bases and study programs given by the Ministry of Education (MINEDUC)²⁰.
- b. *Perception of cognitive functions in the school context:* A survey developed by the researchers using 5/18 items of the Daily Stress Inventory was applied (DSI)²¹. These items are associated with the perception of cognitive functions in the school setting and have already been used in other studies²². The 5 questions used were: How good is your memory? How quickly do you solve a math problem in school? How well do you maintain attention in class without losing concentration? How well can you solve complex tasks in school? and How nervous do you get during a test? It was scored from 0 to 10, where lower values indicated more problems

in the evaluated behaviors and vice versa. Subsequently, to present the results, each behavior was divided into three categories (0-3, 4-6, and 7-10). The categories for classroom memory were poor memory (0-3), average memory (4-6), and good memory (7-10); for quickness to solve a math problems were slow to solve (0-3), average to solve (4-6), quick to solve (7-10); for attention span in class without losing concentration were bad attention span (0-3), average attention span (4-6), and good attention span (7-10); for solving complex tasks were with problems in solving complex tasks (0-3), I with some problems in solving complex tasks (4-6), and without problems solving complex tasks (7-10); and finally, for nervousness during a test were very nervous (0-3), moderate nervousness (4-6), and without nervousness (7-10).

Sleep habits and problems

The questionnaire used to evaluate sleep habits and problems was the Sleep Self-Report (SSR), Spanish version²³. Each item has a 3-point scale to indicate the frequency of each habit: usually (2 = 5 to 7 times a week), sometimes (1 = 2 to 4 times a week), and seldom (0 = never or once a week). The questionnaire has 19 items (3 of them provide additional information, which is not included in any subscale), grouped into 4 subscales as follows: a) sleep quality; b) sleep-related anxiety; c) sleep refusal; and d) bedtime routines. An overall score is obtained by summing the scores of the 16 items (variable total score). Higher scores indicate more sleep-related problems. Cut-off points were used to indicate schoolchildren with and without sleep problems considering the criteria established by Orgilés, Owens, Espada, Piqueras, Carballo²³ which state: 7 for sleep quality, 6 for sleep-related anxiety, 4 for sleep refusal, 3 for bedtime routines, and 16 for the total score.

Socio-school data

The age, sex, and grade of each student and whether or not they participated in the School Integration Program (PIE) were reported.

Statistical analysis

Qualitative variables were presented as absolute frequency and relative percentage frequency, and quantitative variables as mean $\pm$ standard deviation. The distribution of the data was tested with the Shapiro-Wilk test, showing normality in all variables of analysis. In addition, equality of variances was verified with Levene's test using parametric statistics. The chi-square test was used to establish the association between nominal variables. The difference in medians between two different groups was tested with the t-Student test for independent samples. To establish the

linear relationship between performance variables and child sleep, Pearson's correlation coefficient was used. The significance levels used were $p \leq 0.05$ and $p \leq 0.01$.

Results

It was observed that the students were mostly male (53.9%), with an average age of 12 years, and 19.2% belonged to the school integration program. Most of the students perceived themselves as having good memory, being quick to solve mathematical problems, with no problems in solving complex tasks, or nervousness during a test. Males perceived themselves to be faster at solving mathematical problems, with fewer problems solving complex tasks, and less nervous than girls ($p = 0.024$; $p = 0.04$; $p = 0.015$, respectively). Additionally, it was evidenced that girls had better math grades and GPA than boys ($p = 0.007$; $p = 0.002$, respectively) (table 1).

It was observed that 17.1% of the schoolchildren perceived themselves as having sleep problems, specifically, 12.1% indicated having poor sleep quality, 5.5% sleep-related anxiety, 7.2% refusal to sleep, and 81.9% problems with bedtime routines. There were no differences between boys and girls in the score and percentage of schoolchildren with sleep problems (table 2).

School performance according to sleep problems in boys and girls

Figure 1 shows the grades point average of boys (figure 1a, 1b, and 1c) and girls (Figure 1d, 1e, 1f) with and without sleep problems. In relation to the total score of the SSR test, children who indicated having sleep problems had lower grades in language arts ($p = 0.012$), physical education ($p = 0.033$), and GPA ($p = 0.006$). When analyzing the dimensions of the test independently, it was observed that the children who indicated that they had sleep quality problems had lower grades in mathematics ($p = 0.043$), language arts ($p = 0.027$), physical education ($p = 0.026$), and GPA ($p = 0.02$) compared with those children without sleep quality problems. Children who indicated sleep-related anxiety had lower grades in language arts ($p = 0.016$) than children without sleep anxiety. In addition, children who indicated refusal to sleep had lower grades in language arts ($p = 0.032$) and GPA ($p = 0.012$) compared with those children who did not report refusal to sleep.

Regarding the total score of the SSR test, girls who reported having sleep problems had lower grades in language arts ($p = 0.008$) and GPA ($p = 0.015$). When analyzing the dimensions of the test independently, it was observed that girls with sleep quality problems had a lower GPA ($p = 0.030$) compared with those girls without sleep quality problems. In addition, girls with

bedtime routine problems had lower grades in math ($p = 0.046$) compared with girls without such problems (figure 1).

Perception of cognitive functions in the school context, according to sleep problems in boys and girls

When analyzing in boys the perception of cognitive functions according to sleep problems, we can observe that from them, a high percentage presented memory problems in class ($p = 0.000$), slower solving mathematical problems ($p = 0.008$), less attention in class ($p = 0.001$), and greater difficulties in solving complex tasks ($p = 0.000$) compared with boys without sleep problems. When analyzing independently the dimensions of SSR, it was observed that in boys who reported problems in sleep quality, a higher percentage presented less attention in class ($p = 0.017$) and greater difficulties in solving complex tasks ($p = 0.004$) compared with those without problems in sleep quality. Likewise, boys who presented greater refusal to sleep reported a higher percentage of memory problems in class ($p = 0.000$), slower solving mathematical problems ($p = 0.019$), and greater difficulties in solving complex tasks ($p = 0.000$) compared with boys with less refusal to sleep. Additionally, in boys who presented bedtime routine problems, a higher percentage reported nervousness during a test ($p = 0.030$) compared with boys without bedtime routine problems (figure 2).

When analyzing only the girls, those who presented sleep problems showed a higher percentage of memory problems in class ($p = 0.000$), slower solving mathematical problems ($p = 0.005$), less attention in class ($p = 0.000$), greater difficulty in solving complex tasks ($p = 0.024$), and greater nervousness during a test ($p = 0.003$) compared with girls without sleep problems. When the dimensions of the SSR were analyzed independently, it was observed that girls who presented sleep quality problems, a higher percentage indicated having memory problems in class ($p = 0.002$), less attention in class ($p = 0.000$), and greater nervousness during a test ($p = 0.008$) than girls without sleep quality problems. Likewise, girls with sleep-related anxiety presented a higher percentage of memory problems in class ($p = 0.002$) compared with girls without sleep-related anxiety. In addition, in girls with higher sleep refusal, a higher percentage presented slower solving mathematical problems ($p = 0.045$) and less attention in class ($p = 0.005$) than girls with lower sleep refusal (figure 3).

Association between sleep problems, perception of cognitive functions, and grade point average

Table 3 shows the corroboration of the association between the SSR scores, the perception of cognitive functions, and the GPA. Male and female school-

Table 1. School-Social characteristics, perception of cognitive functions in the school context and grades point average, by gender.

Variables	Boys	Girls	All schoolchildren
n (%)	395 (53.9)	338 (46.1)	733 (100)
Age (years) (M±SD)	12.1±1.4	12.0±1.2	12.0±1.3
<i>School Grade Level (Primary school)</i>			
Fifth	94 (23.8)	68 (20.1)	162 (22.1)
Sixth	98 (24.8)	89 (26.3)	187 (25.5)
Seventh	96 (24.3)	102 (30.2)	198 (27.0)
Eighth	107 (27.1)	79 (23.4)	186 (25.4)
<i>School Integration Program (SIP)^{††}</i>			
Yes	88 (22.3)	53 (15.7)	141 (19.2)
No	307 (77.7)	285 (84.3)	592 (80.8)
<i>Perception of cognitive functions in the school context</i>			
<i>Memory in classes</i>			
Bad memory	18 (4.6)	30 (8.9)	48 (6.5)
Average memory	133 (33.7)	109 (32.2)	242 (33.0)
Good memory	244 (61.8)	199 (58.9)	443 (60.4)
<i>Quickness to solve a math problem at school^{††}</i>			
Slow to solve math problems	44 (11.1)	77 (22.8)	121 (16.5)
Average to solve math problems	124 (31.4)	117 (34.6)	241 (32.9)
Quick to solve math problems	227 (57.5)	144 (42.6)	371 (50.6)
<i>Attention span in class without losing concentration</i>			
Bad attention span	71 (18.0)	72 (21.3)	143 (19.5)
Average attention span	162 (41.0)	138 (40.8)	300 (40.9)
Good attention span	162 (41.0)	128 (37.9)	290 (39.6)
<i>Solving complex tasks at school^{††}</i>			
With problems in solving complex tasks	45 (11.4)	64 (18.9)	109 (14.9)
With some problems in solving complex tasks	146 (37.0)	133 (39.3)	279 (38.1)
Without problems solving complex tasks	204 (51.6)	141 (41.7)	345 (47.1)
<i>Nervousness during a test[†]</i>			
Very nervous during a test	72 (18.2)	89 (26.3)	161 (22.0)
Moderate nervousness during a test	101 (25.6)	90 (26.6)	191 (26.1)
Without nervousness during a test	222 (56.2)	159 (47.0)	381 (52.0)
<i>Grade point average (GPA)</i>			
Mathematics (1-7) (M±SD)	5.2±1.00	5.2±1.03	5.2±1.01
Language (1-7) (M±SD) **	5.0±0.82	5.2±0.80	5.1±0.82
Physical Education (1-7) (M±SD)	6.4±0.55	6.4±0.53	6.4±0.54
Cumulative GPA (1-7) (M±SD) **	5.6±0.57	5.7±0.59	5.6±0.58

Qualitative data presented as frequency and percentage and quantitative data as mean ± standard deviation (M ± SD). **= Differences are significant with a $p < 0.01$; *= Differences are significant with a $*p \leq 0.05$. The significant association used was $^{\dagger}p \leq 0.05$ and $^{\dagger\dagger}p \leq 0.01$; n = 733 all schoolchildren.

Table 2. Childhood sleep habits and problems

	Boys	Girls	All schoolchildren
<i>Sleep self-report (M±SD)</i>			
Sleep quality (0-10)	4.2±2.7	4.3±2.5	4.2±2.6
Sleep-related anxiety (0-10)	1.9±2.3	2.4±2.2	2.1±2.2
Sleep refusal (0-6)	1.7±1.7	1.5±1.6	1.6±1.7
Bedtime routines (0-6)	3.9±0.9	3.9±0.8	3.9±0.9
Overall score (0-32)	11.7±5.6	12.1±5.0	11.9±5.3
<i>Sleep problems, n (%)</i>			
Sleep quality	49 (12.4)	40 (11.8)	89 (12.1)
Sleep-related anxiety	20 (5.1)	20 (5.9)	40 (5.5)
Sleep refusal	33 (8.4)	20 (5.9)	53 (7.2)
Bedtime routines	326 (82.5)	274 (81.1)	600 (81.9)
Overall score	69 (17.5)	56 (16.6)	125 (17.1)

Qualitative data presented as frequency and percentage and quantitative data as mean ± standard deviation (M ± SD). **= Differences are significant with a $p < 0.01$; *= Differences are significant with a $*p \leq 0.05$. The association is significant with a p value < 0.05 . n = 733 all schoolchildren.

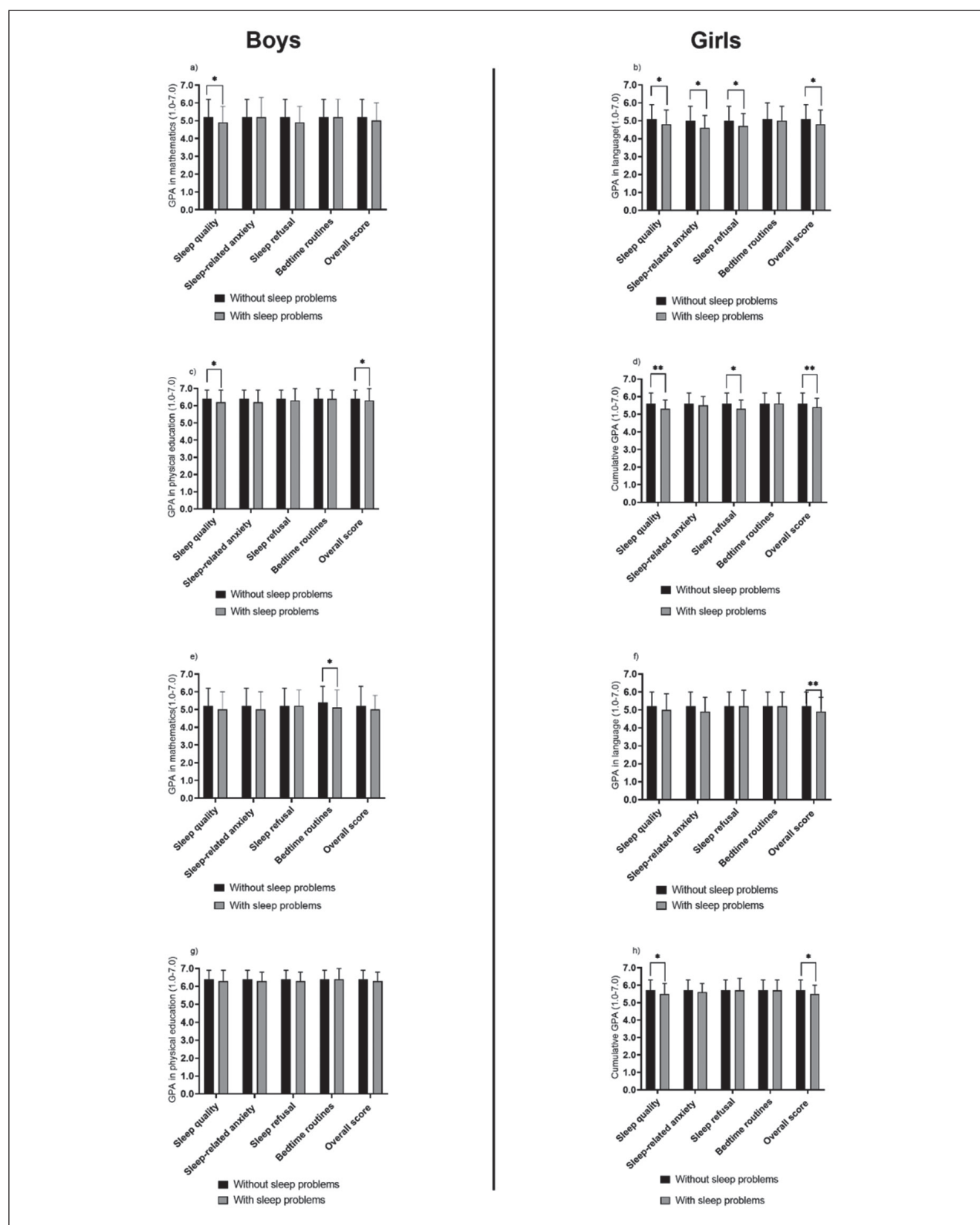


Figure 1. Grades point average according to sleep problems in boys and girls. In Boys: **a)** Average in mathematics, **b)** Average in language, **c)** Average in physical education and **d)** General average. In girls: **e)** Average in mathematics, **f)** Average in language, **g)** Average in physical education and **h)** General average. *The significant differences between the group with and without sleep problems with a p value < 0.05. **The significant differences between the group with and without sleep problems with a value p < 0.01. The variables are presented as mean $\pm$ standard deviation. n = 733.

Boys

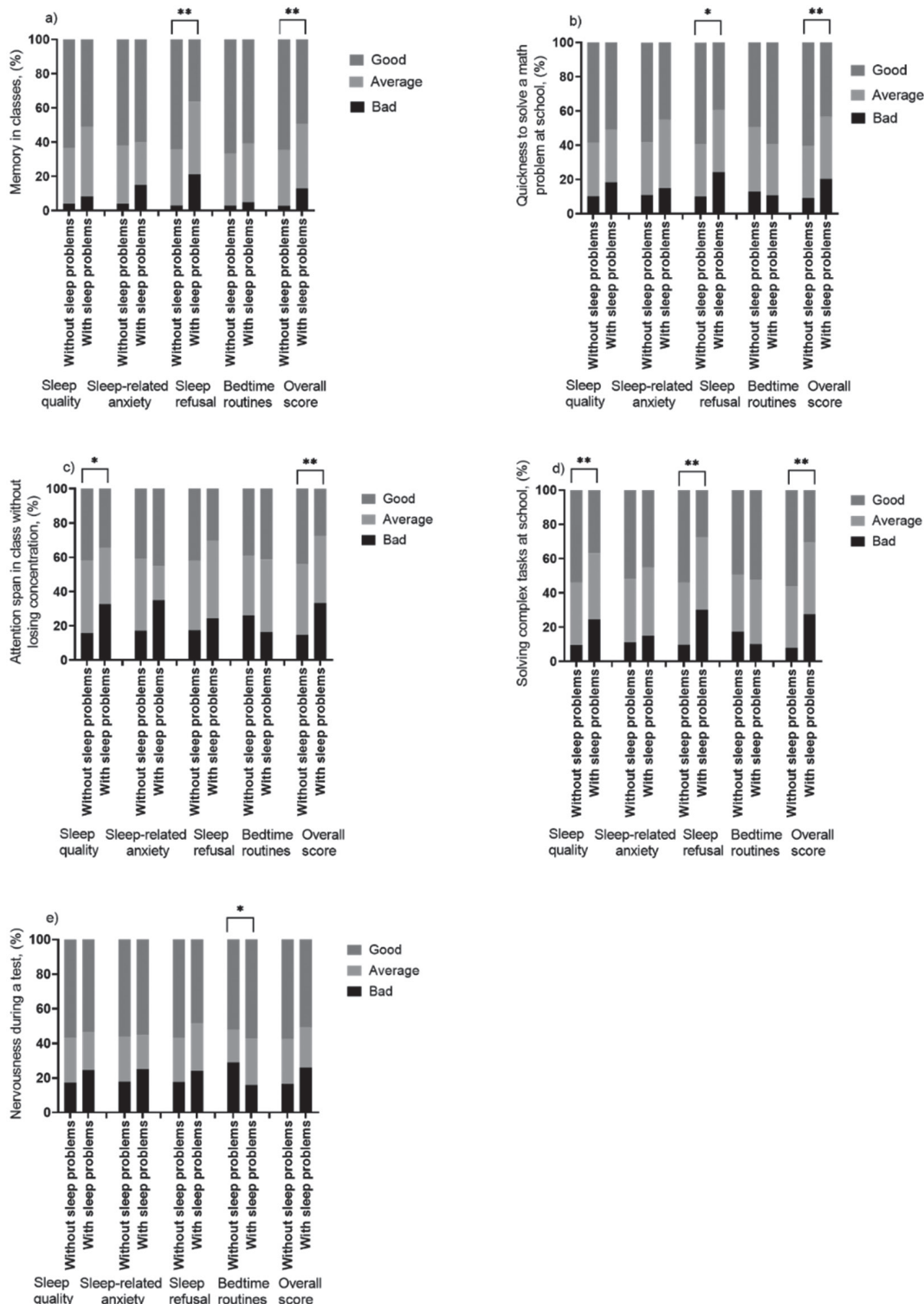


Figure 2. Perception of cognitive functions in the school context according to sleep problems In boys: **a)** Memory in classes, **b)** Quickness to solve a math problem at school, **c)** Attention span in class without losing concentration, **d)** Solving complex tasks at school, **e)** Nervousness during a test. Perception of cognitive functions in the school context are classified into 3 categories: Bad, average, and good *The association is significant between sleep problems and perception of cognitive functions in the school context with a p value < 0.05. **The association is significant between sleep problems and perception of cognitive functions in the school context with a p value < 0.01. The variables are presented in percentage. n = 733.

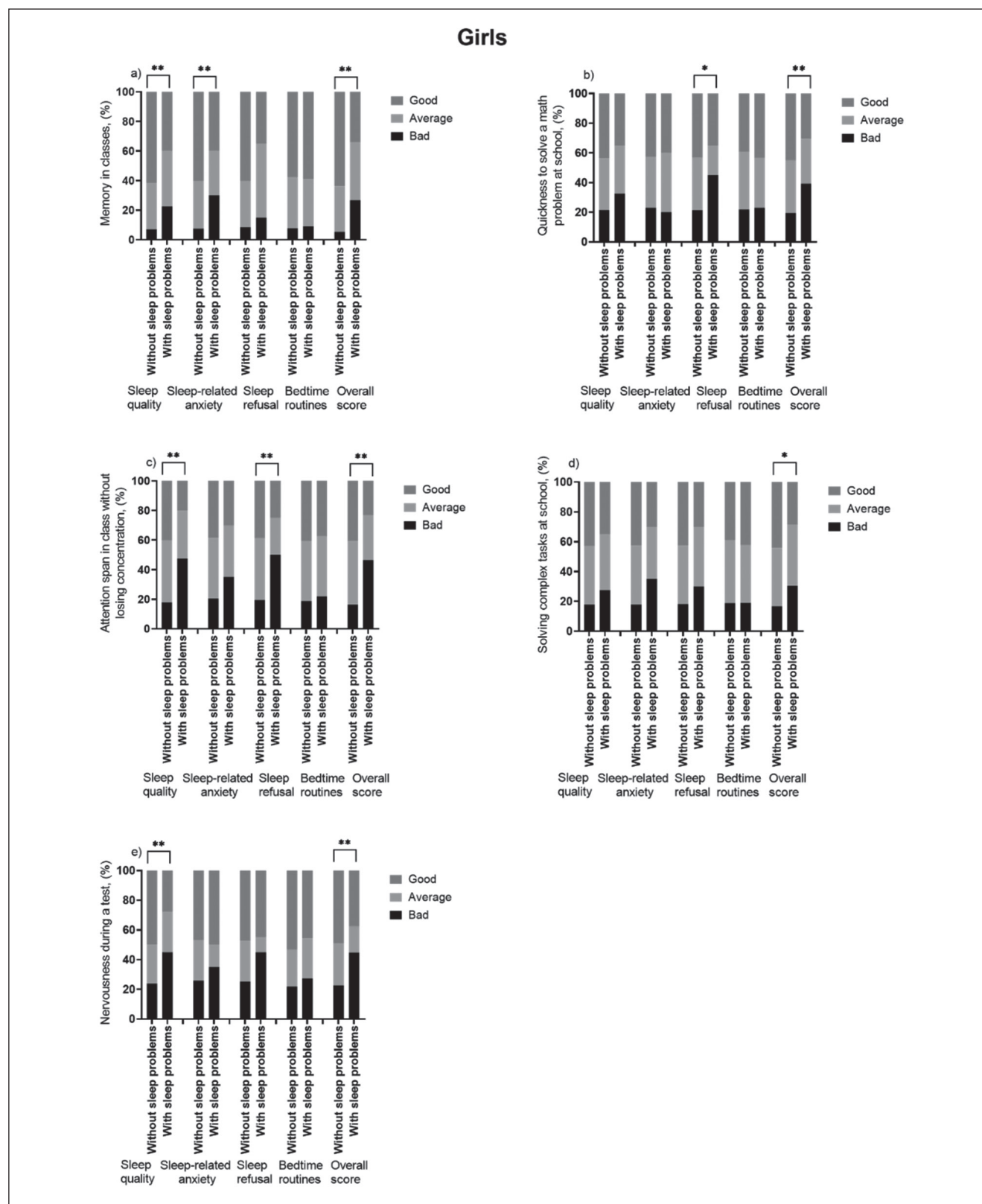


Figure 3. Perception of cognitive functions in the school context according to sleep problems In girls: **a)** Memory in classes, **b)** Quickness to solve a math problem at school, **c)** Attention span in class without losing concentration, **d)** Solving complex tasks at school, **e)** Nervousness during a test. Perception of cognitive functions in the school context are classified into 3 categories: Bad, average, and good *The association is significant between sleep problems and perception of cognitive functions in the school context with a p value < 0.05. **The association is significant between sleep problems and perception of cognitive functions in the school context with a p value < 0.01. The variables are presented in percentage. n = 733.

Table 3. Linear correlation between sleep self-report children, perception of cognitive functions in the school context and grades point average

Auto informe de sueño infantil	Perception of cognitive functions in the school context					Grades point average (GPA)			
	1	2	3	4	5	Mathematics	Language	Physical Education	Cumulative GPA
<i>All schoolchildren</i>									
Sleep quality	-.181**	-.152**	-.236**	-.205**	-.109**	-0.050	-.106**	-.076*	-.122**
Sleep related anxiety	-.121**	-.095*	-.129**	-.158**	-0.048	0.011	-.075*	-.082*	-0.022
Sleep refusal	-.183**	-.175**	-.244**	-.221**	-0.065	-.087*	-.132**	-.089*	-.144**
Bedtime routines	-0.032	-0.045	-0.016	-0.026	0.003	-0.043	-0.004	-0.015	0.001
Overall score	-.202**	-.176**	-.249**	-.240**	-.093*	-0.054	-.125**	-.102**	-.114**
<i>Boys</i>									
Sleep quality	-.158**	-.102*	-.187**	-.186**	-0.012	-0.020	-0.088	-.110*	-.109*
Sleep related anxiety	-0.070	-0.090	-.114*	-.112*	0.001	0.003	-.112*	-.124*	-0.050
Sleep refusal	-.185**	-.194**	-.237**	-.230**	0.002	-0.094	-.114*	-0.096	-.173**
Bedtime routines	-0.010	-0.043	0.018	0.041	0.050	-0.006	0.014	-0.036	0.037
Overall score	-.164**	-.153**	-.208**	-.200**	0.003	-0.038	-.122*	-.139**	-.121*
<i>Girls</i>									
Sleep quality	-.208**	-.208**	-.296**	-.227**	-.220**	-0.087	-.135*	-0.031	-.146**
Sleep related anxiety	-.177**	-0.066	-.141**	-.195**	-0.085	0.020	-0.053	-0.020	-0.013
Sleep refusal	-.186**	-.180**	-.258**	-.224**	-.154**	-0.078	-.146**	-0.085	-0.102
Bedtime routines	-0.056	-0.036	-0.055	-0.099	-0.047	-0.090	-0.037	0.017	-0.053
Overall score	-.247**	-.194**	-.298**	-.283**	-.202**	-0.074	-.142**	-0.048	-.119*

1 = memory in classes, 2 = quickness to solve math problems at school, 3 = Attention span in class without losing concentration, 4 = Solving complex tasks at school, 5 = Nervousness during a test. n = 733 all schoolchildren (n = 395 boys; n = 342 girls). **= The correlation is significant with a p value < 0.01. *The correlation is significant with a value p < 0.05.

children with greater sleep problems, according to the SSR, presented significantly diminished cognitive functions. Likewise, when independently analyzing the dimensions of the SSR, schoolchildren with poor sleep quality showed diminished cognitive functions. A similar situation occurred in schoolchildren who reported having greater sleep-related anxiety and sleep refusal. Also, they reported having less memory in class, slower solving mathematical problems, less attention in class, and greater difficulties in solving complex tasks, but not more nervous. These associations were independent of sex. Regarding bedtime routines, this dimension was not correlated with behaviors associated with cognition in the school context.

Regarding grade point averages, there was an association between male and female students who reported having sleep problems according to the SSR and lower grades in language arts, physical education, and GPA. This association was maintained when the dimensions of the test were independently analyzed, confirming that schoolchildren with lower sleep quality and greater refusal to sleep presented the lowest grades in language arts, physical education, and GPA. Schoolchildren with greater sleep-related anxiety were

associated only with lower grades in language arts and physical education. These associations remained the same in both sexes, although with greater intensity in girls. No association was found between bedtime routines and grade point averages (table 3).

Discussion

The main findings of this study suggest a high prevalence of bedtime routine problems (81.9%). The prevalence of sleep problems (sleep-related anxiety, sleep refusal, and sleep quality) was similar to previous studies reported in Chilean schoolchildren (< 12%)^{7,24}. Schoolchildren of both sexes with sleep problems evaluated with the SSR presented greater memory problems, slower solving mathematical problems, more difficulties in maintaining attention in class, greater difficulties in solving complex tasks, and more nervousness during a test than schoolchildren without sleep problems. In addition, schoolchildren with sleep problems of both sexes had lower grades in mathematics, language arts, physical education, and GPA than schoolchildren without sleep problems.

There were differences between boys and girls in academic performance, which modified the relationship and intensity between sleep disorders and school performance. In this context, current evidence suggests that gender-stereotypical socialization influences the gender differential construction of this self-perception, which could explain why girls perceive themselves with lower cognitive functions than boys or with greater sleep anxiety, although this does not affect their academic performance²⁵. In addition, evidence has shown that girls present differential behavior patterns and health habits compared with boys in the school context, which indicates that girls do less physical activity, use more mobile devices and for longer periods, and present higher levels of anxiety during periods of academic evaluation; however, this does not prevent them from having higher grades than boys^{26,27}.

Delayed sleep onset and duration are considered common sleep problems in adolescents, directly affecting bedtime routines¹². The causes of these problems are associated with biological and psychosocial factors. In relation to the latter, previous evidence indicates that the acquisition of unhealthy lifestyles, a progressive decrease in parental influence over their children's routines, excessive academic pressure, and the use of smart devices during the night increase the probability of presenting sleep routine problems²⁸. In fact, recent research has found a decrease in sleep hours in adolescents due to increased screen time (television, video games, or cell phones)²⁹. In addition, a recent meta-analysis demonstrated the association between the use of these devices at bedtime and sleep problems such as insufficient sleep, poor sleep quality, and excessive daytime sleepiness¹⁰.

Adequate sleep is essential for optimal functioning of cognitive skills, learning, physical and psychological well-being, and regular sleep routines are considered crucial for proper social and emotional development at school. However, a high number of children and adolescents have sleep problems or bad sleeping habits, as evidenced in our study where many students had problems with sleep routines, and often unknowingly experience consequences such as daytime sleepiness, mood swings, and even school absenteeism, affecting attention, memory, and academic performance^{30,31}. In addition, adolescents' ability to process information is at risk when they are sleep-deprived or have sleeping problems³².

Current literature supports our findings on the association between sleep problems, perceived impaired cognitive functions, and poor school performance. One study showed that attention, reaction speed, and cognitive processing speed are negatively affected after a sleepless night³³. In contrast, under ideal sleeping conditions, adolescents can achieve optimal academic

performance and even solve more challenging problems³². In relation to memory, sleep also plays a role during adolescence^{34,35}. A study conducted in adolescents (16.7 ± 1.0 years) showed that sleep deprivation (7 nights of partial deprivation) increased the probability of incorporating erroneous information during a memory retrieval test³⁶. Additionally, long-term retention of classroom learning is compromised after sleep deprivation³⁷.

What are the contributions and implications of this research?

The findings of this research support the current evidence and contribute to the limited evidence from Latin American studies which suggest an inversely proportional association between sleep problems and lower academic performance in elementary school children. To date, this study becomes the most updated evidence that shows a high prevalence of sleep routine problems and a relationship between sleep problems and lower school performance and worse perception of cognitive functions in schoolchildren from public schools in the province of Biobío, Chile. This research highlights the importance of systematically analyzing and monitoring children's sleep habits in order to detect problems early and, therefore, their implications on health and school performance can be potentially avoided. In addition, these findings can be considered by professionals and school administrators to reflect on the potential negative impact of poor sleep hygiene on the performance of their students.

Limitations of the study

The causes of poor school performance are not explained by a single risk factor, but rather depend on multiple risk factors acting simultaneously. In this sense, the study design allowed us to analyze the association between sleep problems and school performance and did not determine the etiology of sleep disorders or poor academic performance, nor did we analyze social determinants (age, sex, race, ethnicity, place of residence), current health condition, genetic inheritance, and personal, family or school context characteristics that could be associated with sleep disorders or academic performance.

In addition, self-reporting instruments were used to record sleep hygiene, health characteristics, lifestyles, and perception of cognitive functions, which could lead to bias due to under- or overestimation of the variables studied. However, the use of questionnaires and online data collection has proven to be an acceptable method in epidemiological surveillance studies, especially at times when confinement makes it difficult to do so in). On the other hand, children belonging to the PIE were not excluded, because a large percentage of them (92%) had transient Special Edu-

cational Needs (SEN) and, of them, most (90%) had diagnoses of Specific Language Impairment (SLI), so it was considered that their condition should not affect school performance.

Future research lines

Researchers are encouraged to deepen in the interaction that the studied variables may have, as well as the association between current life habits and school performance. For example, how academic performance may be affected by bedtime, sleeping space, indiscriminate use of electronic devices, apps, and cell phones, a low level of physical activity, and unhealthy eating habits or routines. Recent studies developed in Chile are already beginning to shed light on the association between unhealthy habits in childhood and poor school performance.^{3,4,39}

Conclusions

Schoolchildren of both sexes showed a high prevalence of bedtime routine problems. In addition, those who reported sleep problems were perceived as having diminished cognitive functions and obtained lower grade point averages than schoolchildren without sleep problems. These findings reinforce the need for developing programs to screen for sleep problems and to promote healthy sleep habits that consider the different health conditions, routines, and lifestyles of

schoolchildren in our country since sleep habits could be a relevant variable for better school performance.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

Financial Disclosure

Authors state that no economic support has been associated with the present study.

References

- Dumuid D, Olds T, Martín-Fernández JA, et al. Academic Performance and Lifestyle Behaviors in Australian School Children: A Cluster Analysis. *Heal Educ Behav*. 2017;44(6):918-27.
- Abriñani MG, Lucà F, Favilli S, et al. Lifestyles and Cardiovascular Prevention in Childhood and Adolescence. *Pediatr Cardiol*. 2019;40(6):1113-25.
- Burrows R, Correa-Burrows P, Reyes M, et al. High cardiometabolic risk in healthy Chilean adolescents: Associations with anthropometric, biological and lifestyle factors. *Public Health Nutr*. 2016;19(3):486-93.
- Gaete-rivas D, Olea M, Granfeldt G, et al. Hábitos alimentarios y rendimiento académico en escolares chilenos de quinto a octavo año básico / *Rev Chil Nutr* 2021; 48(1):41-50.
- Johansson AEE, Petrisko MA, Chasens ER. Adolescent Sleep and the Impact of Technology Use Before Sleep on Daytime Function. *J Pediatr Nurs*. 2016;31(5):498-504.
- Owens J, Au R, Carskadon M, et al. Insufficient sleep in adolescents and young adults: An update on causes and consequences. *Pediatrics*. 2014;134(3):e921-32.
- Bugueño M, Curihual C, Olivares P, et al. Calidad de sueño y rendimiento académico en alumnos de educación secundaria Quality of sleep and academic performance in high school students. *Rev Med Chil*. 2017;145:110-14.
- Masalán P, Sequeida J, Ortiz M. Sleep in schoolchildren and adolescents, their importance and promotion through educational programs. *Rev Chil Pediatr*. 2015;84(5):554-64.
- Kim J, Noh JW, Kim A, et al. Relationships between sleep patterns, health risk behaviors, and health outcomes among school-based population of adolescents: A panel analysis of the Korean children and youth panel survey. *Int J Environ Res Public Health*. 2019;16(13):1-9.
- Carter B, Rees P, Hale L, et al. Association between portable screen-based media device access or use and sleep outcomes a systematic review and meta-analysis. *JAMA Pediatr*. 2016;170(12):1202-8.
- Wang X, Li Y, Fan H. The associations between screen time-based sedentary behavior and depression: a systematic review and meta-analysis. *BMC Public Health*. 2019;19(1):1-9.
- Foerster M, Henneke A, Chetty-Mhlana S, Rösli M. Impact of adolescents' screen time and nocturnal mobile phone-related awakenings on sleep and general health symptoms: A prospective cohort study. *Int J Environ Res Public Health*. 2019;16(3):1-14.
- Suardiaz-Muro M, Morante-Ruiz M, Ortega-Moreno M, et al. Sleep and academic performance in university students: A systematic review. *Rev Neurol*. 2020;71(2):45-53.
- Cohen-Zion M, Shiloh E. Evening chronotype and sleepiness predict impairment in executive abilities and academic performance of adolescents. *Chronobiol Int*. 2018;35(1):137-45.
- Lo JC, Ong JL, Leong RLF, et al. Cognitive performance, sleepiness, and mood in partially sleep deprived adolescents:

- The need for sleep Study. *Sleep*. 2016;39(3):687-98.
16. Atrooz F, Salim S. Sleep deprivation, oxidative stress and inflammation. *Adv Protein Chem Struct Biol*. 2020;119:309-36.
 17. Patel AK, Araujo JF. Physiology, Sleep Stages. StatPearls Publishing; 2021(1):1-10.
 18. Peever J, Fuller PM. The Biology of REM Sleep. *Curr Biol*. 2017;27(22):R1237-48.
 19. Ackermann S, Rasch B. Differential effects of non-REM and REM sleep on memory consolidation? *Curr Neurol Neurosci Rep*. 2014;14(2):1-10.
 20. Cigarroa I, Sarqui C, Palma D, et al. Estado nutricional, condición física, rendimiento escolar, nivel de ansiedad y hábitos de salud en estudiantes de primaria de la provincia del bio bio (Chile): estudio transversal. *Rev Chil Nutr*. 2017;44(3):209-17.
 21. Encina Agurto YJ, Ávila Muñoz MV. Validación de una escala de estrés cotidiano en escolares chilenos. *Rev Psicol*. 2015;33(2):363-85.
 22. Solis-Urra P, Olivares-Arancibia J, Suarez-Cadenas E, et al. Study protocol and rationale of the "cogni-action project" a cross-sectional and randomized controlled trial about physical activity, brain health, cognition, and educational achievement in schoolchildren. *BMC Pediatr*. 2019;19(1):1-16.
 23. Orgilés M, Owens J, Espada JP, et al. Spanish version of the Sleep Self-Report (SSR): Factorial structure and psychometric properties. *Child Care Health Dev*. 2013;39(2):288-95.
 24. Aguilar M, Vergara F, Velásquez E, et al. Actividad física, tiempo de pantalla y patrones de sueño en niñas chilenas. *An Pediatr (Barc)*. 2015;83(5):304-10.
 25. Marchant Orrego T, Milicic Müller N, Pino García MJ, et al. La Autoestima en Alumnos de 3º a 8º Básico. Una Mirada por Nivel de Escolaridad y Género Self-Esteem in Students of 3th to 8th Grade. A Review by School Grade and Gender. *Rev Iberoam Evaluacón Educ*. 2017;10(2):111-25.
 26. Carbonell X, Chamarro A, Oberst U, et al. Problematic use of the internet and smartphones in university students: 2006-2017. *Int J Environ Res Public Health*. 2018;15(3):1-13.
 27. Hilt JA, Adventista Mariano Moreno I. Dependencia del celular, hábitos y actitudes hacia la lectura y su relación con el rendimiento académico Cell phone dependence, habits and attitudes towards reading and its relationship with academic performance. *Rev Investig Apunt Univ*. 2019;9(3):103-16.
 28. Kaur H, Bhoday HS. Changing adolescent sleep patterns: Factors affecting them and the related problems. *J Assoc Physicians India* 2017;65(March):73-7.
 29. Carter B, Rees P, Hale L, et al. Association between portable screen-based media device access or use and sleep outcomes a systematic review and meta-analysis. *JAMA Pediatr*. 2016;170(12):1202-8.
 30. Singh R, Suri JC, Sharma R, et al. Sleep Pattern of Adolescents in a School in Delhi, India: Impact on their Mood and Academic Performance. *Indian J Pediatr*. 2018;85(10):841-8.
 31. Ren L, Hu BY. The Relative Importance of Sleep Duration and Bedtime Routines for the Social-Emotional Functioning of Chinese Children. *J Dev Behav Pediatr*. 2019;40(8):597-605.
 32. Cohen-Zion M, Shabi A, Levy S, et al. Effects of Partial Sleep Deprivation on Information Processing Speed in Adolescence. *J Int Neuropsychol Soc*. 2016;22(4):388-98.
 33. Louca M, Short MA. The effect of one night's sleep deprivation on adolescent neurobehavioral performance. *Sleep*. 2014;37(11):1799-807.
 34. Leong RLF, van Rijn E, Koh SYJ, et al. Sleep improves memory for the content but not execution of intentions in adolescents. *Sleep Med*. 2019;56:111-6.
 35. Lo JC, Bennion KA, Chee MWL. Sleep restriction can attenuate prioritization benefits on declarative memory consolidation. *J Sleep Res*. 2016;25(6):664-72.
 36. Lo JC, Chong PLH, Ganesan S, et al. Sleep deprivation increases formation of false memory. *J Sleep Res*. 2016;25(6):673-82.
 37. Cousins JN, Wong KF, Chee MWL. Multi-Night Sleep Restriction Impairs Long-Term Retention of Factual Knowledge in Adolescents. *J Adolesc Heal*. 2019;65(4):549-57.
 38. Guzmán-Muñoz E, Concha-Cisternas Y, Oñate-Barahona A, et al. Factors associated with low quality of life in Chilean adults during the COVID-19 quarantine. *Rev Med Chil*. 2020;148(12):175-66.
 39. Zapata-Lamana R, Ibarra-Mora J, Henríquez-Beltrán M, et al. Aumento de horas de pantalla se asocia con un bajo rendimiento escolar. *Andes pediatr*. 2021;92(4):565-75.