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Relation between sleep and visuospatial skills in students from a public school

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Abstract

The relation between the sleep and the visuospatial skills was evaluated in 31 students from a public school. For the analysis of sleep, the parents of volunteers answered a sleep evaluation questionnaire and the sleep diary. The visuospatial performance was evaluated by Wechsler Intelligence Scale for Children (WISC-III), through the subtest Picture Completion, the Perceptual Organization Index and the Performance IQ Scale. In accordance with the results, 72% of the students presented regular sleep and good sleep length. The visuospatial performance was deficient in subtest Picture Completion for 56% of the students, and on the Performance IQ Scale for 60% of the students. Significant correlations were verified between early sleep onset (*rho* = -0.40, $p < 0.05$) and regular sleep (*rho* = -0.39, $p < 0.05$) with the visuospatial performance. It was concluded that sleeping early and having a regular sleep may contribute to a better visuospatial performance.

Keywords: sleep; cognition; students.

Resumo

Avaliou-se a relação entre o sono e a visuoespacialidade em 31 estudantes de uma escola pública. Para a análise do sono, foram preenchidos, pelos pais dos voluntários, uma ficha de avaliação do sono e o diário do sono. O desempenho visuoespacial foi avaliado pela Escala de Inteligência Wechsler para Crianças (WISC-III), utilizando o subteste Completar Figuras, o índice fatorial Organização Perceptual e a Escala QI de Execução. De acordo com os resultados, 72% dos estudantes apresentaram sono regular e boa duração. O desempenho visuoespacial foi deficiente no subteste Completar Figuras para 56% dos estudantes, e na Escala QI de Execução para 60% dos alunos. Foram verificadas correlações significativas entre início do sono cedo (*rho* = -0,40, $p < 0,05$) e sono regular (*rho* = -0,39, $p < 0,05$) com o desempenho visuoespacial. Conclui-se que dormir mais cedo e ter um sono regular podem contribuir para um melhor desempenho visuoespacial.

Palavras-chave: sono; cognição; estudantes.

Nowadays, there have been more and more complaints about sleep among the population in school-age (Sadeh, Gruber, & Raviv, 2002), and it is estimated that approximately one third of all the children suffers of sleep disorder (Klein & Gonçalves, 2008). A great part of these complaints might be related to alterations in sleep, too early awakening, sleep fragmentation, or sleeping at irregular times. Most of the times, these alterations are resulting from changes in the school times (early start of classes), crescent academic demands, and also extracurricular activities in which kids are involved during the day. This situation requires that students sleep later to accomplish the demands, and wake up earlier, what diminishes those hours reserved for sleeping (Mendes, 2008; Nielson, Deegan, Hung, & Nunes, 2010; Orzel-Gryglewska, 2010).

Consequently, an instability might be created between the mechanisms that regulate sleep, namely, the homeostatic process S and the circadian process C (Borbély & Achermann, 2000). While process S refers to sleep regulation depending on the amount of sleep and wake, the process C suggests that the alternation between periods of high and low propensity to sleep is controlled by an endogenous circadian pacemaker, which is basically independent from sleep and wake. In other words, the relation of balance between these two systems will determine the resting and awakening moments (Van Dongen & Dinges, 2000).

Sleep deprivation or fragmented sleep, for example, is a result from the instability of these two systems and might lead to poor sleep quality that, in its turn, is associated to a series of behavioral and health alterations, such as humor disorder, depression, impulsivity, and cognitive alterations (Paavonen et

al., 2010; Steenari et al., 2003), which interferes in the academic performance (Nixon et al., 2005). Among the consequences of cognitive functioning, memory loss, reasoning, executive functions, psychomotor vigilance, visual perception, and visuospatial skills are highlighted (Fallone, Acebo, Seifer, & Carskadon, 2005; Zerouali, Jemel, & Godbout, 2010).

Visuospatial skills, one of the cognitive process affected by sleep deprivation (Paavonen et al., 2010), refers to the individuals' capacity of realizing his location and objects location moving in the space, as well as perception of the location relation between these objects and the individual himself (Manning, 2005). The visuospatial skills might be observed in tasks that involve keeping relative orientation on objects that move in the space, perception and transformation of visual shapes and images and perception of bi and tridimensional figures (Gomes & Borges, 2009).

Investigations on sleep in adults and kids through NeuroImage techniques as by Positron Emission Tomography and Functional Magnetic Ressonance (Orzel-Gryglewska, 2010) identified alterations in some cortical areas related to visual functions in sleep deprived participants, as visual cortex, where visual perception happens, parietal cortex, involved with visuospatial skills and, also, location and movement of objects, and inferotemporal cortex, related to perception and recognition of objects. These alterations indicated that sleep deprived individuals might make perceptual mistakes when trying to properly process the visual stimulations of the environment (Kandel, Schwartz ,& Jessel, 2003).

Investigations in the sleep deprived adult population have found a series of alterations in the visual perception that might contribute for damages in the visuospatial skills. Among the alterations, the tunnel vision effect has been found (failure in the perception of visual information present in the periphery of visual field) and a variety of visual mistakes, such as failures in the discrimination between close or similar visual stimulations, identification of visual information and mistakes in detection or omission of present visual stimulations (Roge & Gabaude, 2009; Shorrock, 2007). These mistakes and alterations might cause loss for adults and kids, as they reduce the individual's capacity in processing and integrating visual information in space, as a whole significant and relevant, which might produce the failures (Russo et al., 2005).

Paavonen et al. studies (2010) done with 8-year-old children intended to investigate the influence of the duration and quality of sleep on the visuospatial performance through Wechsler Intelligence Scale for Children (WISC-III). The results showed that the minor performance in visuospatial skills on the Block design subtest was associated to the short sleep duration (variable of sleep that implicates in its quality), and not to the poor sleep quality. The data suggests that variables referring to the pattern of sleep might have an important role in the cognitive performance.

The authors also discussed that the impact of sleep loss on visuospatial skills might be higher in individuals during their childhood or youth than during adulthood, because the first ones do not have the compensatory mechanisms present in adults, which make them more vulnerable to the negative effects of sleep deprivation in cognition. The compensatory mechanisms are constituted of skills acquired through experience or even self development that allow adults to deal with it in a less hurtful way when comparing to the youngest ones with difficulties caused by sleep deprivation (Paavonen et al., 2010). Among the compensatory mechanisms in adults, there are more developed cognitive skills due to their age, which allows them to acquire the capability to search other resources more efficiently, when others are harmed. Besides, during the first childhood, the fast growth and cerebral maturation might increase child's vulnerability to the environments risks, as an inadequate sleep (Paavonen et al., 2010; Sadeh, Dahl, Shahar, & Rosenblat-Stein, 2009).

However, even though some data from literatures indicates that a correlation between cognitive deficits and poor sleep quality, the majority of studies includes a well fragmented set of cognitive tests, which makes it difficult to comprehend what specific cognitive aspects are affected by poor sleep in children. Furthermore, investigations that represent the reality of Brazilian students regarding the relation between sleep and visuospatial skills are scarce in literature.

Therefore, studies on visuospatial skills in the school-age population need to be explored, due to the impact that such losses have in scholar and daily activities. As visuospatial skills are fundamental to comprehend, represent, organize, and situate in relation to information on the environment (Spence & Feng, 2010). Besides, researches indicate that visuospatial skills are important to math functions and aptitude directly related to scholar performance (Hazin, Leitão, & Falcão, 2009). Therein, this study intends to evaluate the relation between the pattern of sleep and visuospatial skills in students of basic education in a public school, with the intention of gathering better evidence on this relation.

Method sample

The research, of descriptive character, was done with students of the fourth grade of basic education from a public school who studied in the morning turn, from 7h to 11h30 a.m.. The initial sample was constituted of 50 students, with average age between 9.64 (*SD* = 1.59) years old, with 50% of the individuals being male.

After using the criteria of inclusion and exclusion, the sample with 50 participants was reduced to a total of 42 individuals. The criteria of inclusion were regularly frequenting classes and not having a historic of psychotropic drugs use. In relation to the criteria of exclusion were considered the regular use of psychotropic drugs, the diagnosis of mental health problems or neurological disorders, and serious sensory or motor problems. These pieces of information were obtained through consulting people responsible for the participants in the research.

The individuals were informed of the study purposes and the eminently voluntary character of their participation, and also that they could quit at any time they wanted, without having to justify it. The experimental protocol had been previously approved by the Research Ethics Committee from the Federal University of Rio Grande do Norte (protocol n. 100/2010) and the people responsible for the participants signed a Free and Clarified Consent Term for the participation in the research.

Protocols and procedures

Before starting to collect data, the purposes of the research were explained to the people responsible for the children, in a meeting at school, the Free and Clarified Consent Term was passed again to them in order to be signed, and also the sleep evaluation questionnaire to be answered. Afterwards, the students took home a questionnaire, for the people responsible for them to fill in, that contained socioeconomic questions, in order to trace the profile of the sample, as well as the Sleep Diary to be filled in during the period stipulated for evaluation. The protocols of sleep evaluation were:

Sleep evaluation questionnaire. indirectly based in a questionnaire that Beijamini (2008) used in his study, and that included questions on teenagers sleep habits. The sleep evaluation questionnaire contained closed questions that characterized the sample as to some more specific information, such as the presence of complaints about sleep (insomnia and excessive morning sleepiness), occurrence of naps during the day, use of medication, among other questions. They were organized in a compound way and with proper language to the sociocultural context of the answerer, as in "Besides going to school, do they do anything else? If yes, what? In what time of day?"

Sleep Diary. adapted from the version used by Louzada (2000), during the estimated period for data collection, this instrument evaluated quantitatively the sleep through register of sleeping and awakening times, as well as other pertinent information, such as rest or fatigue right after awakening and the presence of nap times during the day. It was organized in a way that parents could mark (when marking the blank spaces) the times of night (night sleep) or day (naps) in which kids effectively slept in each of the 15 days evaluated with the Diary.

For the cognitive evaluation, the Wechsler Intelligence Scale for Children (WISC-III) was applied before the beginning of the sleep evaluation period. It is a clinic instrument, of individual application, which evaluates the intellectual capacity of individuals between the age of 6 and 16. The WISC-III is composed of 13 subtests, adapted for the Brazilian sample, which evaluate several dimensions of the cognitive skill. They are organized in these kinds of Subtests: Verbal, of Execution, Supplementary, IQ Scale, and Factorial Index (Cruz, 2005).

The analyses were concentrated in the considerate points of the subtest and of the factorial index that allow the investigation of visuospatial skills in the individuals. Therein, the Picture Completion subtest, task in which figures with an important element missing are presented and its name must be indicated, was analyzed. This subtest is utile in the evaluation of the capability of part-whole perception, recognition, visual memory, and organization of reasoning. The Perceptual Organization factorial index was also evaluated, and it consists of non-verbal reasoning measure and it includes the considerate scores of the non-verbal subtests from WISC. The analysis was complemented with the Performance IQ Scale, one of the measures integrated from WISC intellectual functioning, and it consists of tests that include visuospatial performance.

Data analysis

For the statistic analysis we used *SPSS Statistic, Statistical Package for the Social Sciences* (version 17.0). The Kolmogorov-Sminorv test was used to evaluate the existence of normality in the referred data (in the variable Picture Completion $p = 0.04$, in Perceptual Organization $p = 0.01$, and in Performance IQ Scale $p = 0.04$). Descriptive analyses (average and pattern deviation frequencies) and statistic tests were also done.

For the paired sample (as the sleep variables are analyzed in two moments, school days and weekends), the Wilcoxon test was used. It compared the means of sleep variables (bedtime, length and regularity) obtained in school days, in relation to those obtained during the weekends. The Spearman Correlation Test was used to verify the occurrence of correlations between the sleep and the WISC variables.

Results

Since 73.81% of the individuals from the first sample returned the Sleep Diaries in the evaluation period, the final number of participants decreased to 31 individuals. According to the data obtained with the Socio-Demographic Questionnaire, the average age of the 31 participants was 10.0 ($SD = 1.50$) years old, in which 46.2% was male and 53.8%, female. As the majority of families had a monthly income around the minimum wage (74.1%), there were families of low socioeconomic conditions. This reflected in the number of electronic equipments they had at home, and points out the limited access to the means of communication including computer (7.4% of the families had one). Even so, in a compensatory way, children found other ways to access a computer, for example, in Lan gaming centers.

The data obtained through the Sleep Diary (according to the Figure 1) suggested that individuals slept during the week more than 8 daily hours ($M = 8.77$, Md = 8.7, $SD = 0.19$), with sleep time starting a little before 10 p.m. (M = 21:42, Md = 21:37, SD = 0:12). With a small variation in the pattern deviation of the average bedtimes, it was possible to find regularity in the beginning hours of sleep of the individuals during school days and weekends. The Wilcoxon test was used to verify the existence of significant differences in the sleep variables between school days and weekends. Data showed that there were no significant differences for the variables in the bedtime ($Z = -0.73$, $p = 0.46$), duration ($Z = -1.83$, $p = 0.07$), and sleep regularity ($Z = -1.83$, $p = 0.07$), which suggests that individuals had not slept in times meaningfully different throughout the week, nor even had slept meaningfully more (if compared to weekdays and weekends).

The data obtained through WISC-III (Table 1) showed that the considerate points of individuals in Performance IQ Scale were below the expected for their age (Kaufman, 1994). The data suggested that individuals showed a bordering performance in IQ. As to the performance in Picture Completion subtest the averages were below the expected, and indicate that the considerate points representing the performance in visual-spatial skills were below the stipulated value for average performance, which is 8 points (Figueiredo, 2002).

However, in relation to the Factorial Index Perceptual Organization (that includes several subtests that evaluate

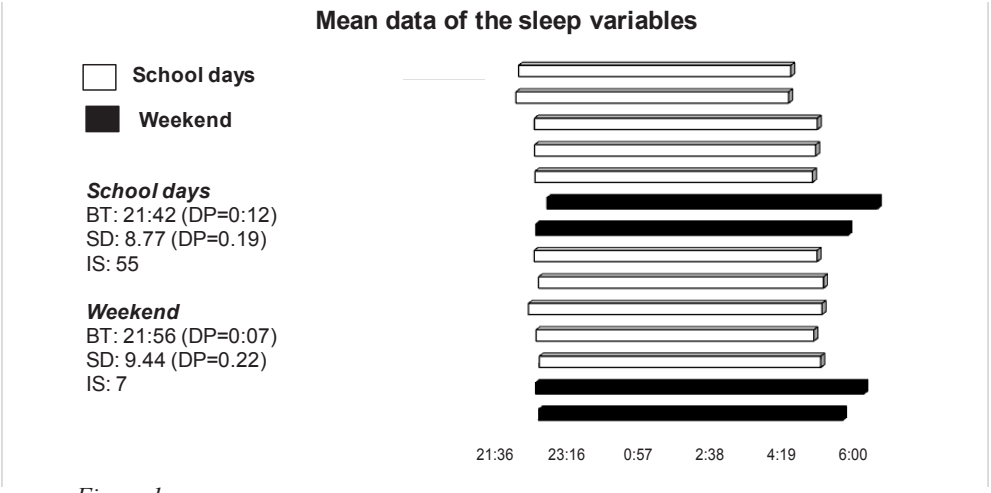

Figure 1
Mean of the sleep variables in students participating in the sample (n = 31), evaluated for 15 days. BT: Bedtime; SD: Sleep Duration; SI: Sleep Irregularity

visuospatial performance), it was verified that the averages pointed to a medium-low performance, and suggested deficits in the visuospatial performance. According to the categories studied by Sattler (1992) to identify the cognitive potentialities and debilities, what he found demonstrated that IQ and visuospatial performance of the students are low.

Table 1
Mean and Median of the Considerate Points Obtained Through Individuals that Composed the Subtest Sample, Factorial Index and Scale Evaluated in WISC.

Variables (considerate points)	Mean	Median	Standard Deviation
Subtest			
Picture Completion	6.84	6.0	3.60
Factorial Index			
Perceptual Organization Index	29.52	32.0	11.20
Scales			
Performance IQ	35.93	40.0	13.45

The Spearman Correlation Test was used to verify the existence of correlations between visuospatial skills and the averages of sleep variables in bedtime, length, and regularity (Table 2). There were no significant correlations between the Picture Completion subtest, the Perceptual Organization index, and the Performance IQ Scale, which evaluated visuospatial skills and the sleep duration. Data suggested that the below average visuospatial performance was not correlated to the sleep adequate duration (in school days and weekends) of the individuals.

Negative and weak correlations were found, meaningfully statistics, between the bedtime in school days and the Perceptual Organization index (*rho* = -0.40, $p < 0.05$) and the Scale of Execution (*rho* = -0.39, $p < 0.05$). These findings suggest that the earlier individuals slept during weekdays the better was their visuospatial performance. It was also verified a significant negative correlation between regularity during the week (*rho* = -0.39, $p < 0.05$) and the Picture Completion subtest, which showed that the less irregular the sleep of individuals during the week, the better their performance in tasks that required the use of visuospatial skills. These results suggest that the early and regular bedtime might contribute to a better performance in visuospatial activities.

Discussion

The purpose of this study was to investigate a possible association to the pattern of sleep-wake cycle on the visuospatial performance in students of basic education. The sleep evaluation occurred during the period of 30 days with 31 individuals (among children and teenagers), who were also evaluated as to their performance in tasks that demanded the use of visuospatial skills.

The individuals had a regular sleep and with appropriate duration for their age, during school days and weekends. Seo et al. (2010) and Touchette et al. (2007) studies corroborated our findings. Seo et al. (2010) found that evaluated children and teenagers (age between 7 and 12 years old) slept average at 10:30 p.m.. Touchette et al. (2007) found that the majority of the individuals (50.30%) participating in his research had slept around 10 hours per night, while 38.90% slept around 11 hours per night. Such data pointed out that an average of 9 hours of sleep per night, with bedtime around 9-10 p.m., might be considered proper for the evaluated age group in the present study.

Regarding the visuospatial performance in individuals evaluated by WISC-III, it was found through the results obtained with the Picture Completion subtest, the Perceptual Organization index, and the Scale of Execution a deficient performance in visuospatial skills. Taking into account, firstly, the scores of the first two indexes, the tasks that demanded from individuals to use recognition, interest, attention to the environment, concentration, and perception of part-whole relations, besides discrimination of essential and non-essential aspects (Souza,

Table 2
Correlations Between the Mean of Variables in the Sleep Diary (Bedtime, Length, and Regularity) and the Development in the Subtest, Factorial Index and Scale of WISC of the Individuals Participating in the Research. BT: Bedtime (h:min); SD: Sleep Duration (h); SI: Sleep Irregularity (min); rho: Spearman Correlation Test.

Variables	School Days						Weekends					
	BT		SD		IS		BT		SD		SI	
	rho	*p*	*rho*	*p*	*rho*	*p*	*rho*	*p*	*rho*	*p*	*rho*	*p*
Subtest												
Picture Completion	-0.33	0.70	0.28	0.12	-0.39	0.03*	-0.34	0.06	-0.04	0.81	-0.15	0.43
Factorial Index												
Perceptual Organization	-0.40	*0.02	0.28	0.12	-0.29	0.11	-0.34	0.06	-0.11	0.55	-0.19	0.30
Scale												
Performance IQ	-0.39	*0.03	0.28	0.12	-0.27	0.14	-0.33	0.08	-0.10	0.59	-0.15	0.44

*Statistically significant correlation ($p < 0.05$)

n/d), which means, factors that characterize the visuospatial skills, had a low performance. Compatible to these findings, 484 children with age around 7.4 years old and who studied in public and private schools were evaluated with WISC in relation to several cognitive processes. Their results revealed that 39% of them showed a visuospatial performance below the expected, according to the scores obtained in the Picture Completion subtest (Guardiola, Ferreira, & Rotta, 1998).

The findings on IQ, evaluated by the Performance IQ Scale, showed a performance below expected for their age group (Figueiredo, 2002). Hence, the level in which the non-verbal abilities of the individual are developed, the capability to integrate perceptual stimulus and motor answers, and the capability to work in concrete situations in a agile way are characteristics linked to the ability of evaluating visuospatial information (Souza, n/d) in the present study. All of them had a deficient performance when evaluated by the Performance IQ Scale.

A better visuospatial and IQ performance were expected, due to the development phase in which individuals of the sample were. In the transition between childhood and youth, the cognition shows substantial changes in parallel to the structural changes in the brain (Lange, Froimowitz, Bigler, & Lainhart, 2010). IQ measures obtained through tests that evaluated the cognitive capabilities have been correlated in studied with alteration in cerebral volume, current from the development phase in which individuals are (Shaw et al., 2006). In the Blakemore and Choudhury study (2006), for example, it was found an increase in the volumes of white and gray matter in the brain according to aging, which was corroborated by other studies.

Such neuroanatomic changes also include the frontal lobe (Killgore, Kendall, Richards, & McBride, 2007), cerebral region responsible for the most complex human cognitive abilities, as planning of sequential actions, standardization, and emission of social and motor behaviors, the emotional automatic behavior and memory, among others (Costa, Azambuja, Portuguez, & Costa, 2004). Therefore, it was imagined that IQ levels of individuals in the present study would accompany the tendency expected to occur structural changes in the brain.

The deficits of performance in spatial reasoning and IQ, identified in the sample, might be related to the socioeconomic context, since the students who participated in the study belonged to families of low socioeconomic level. While in our sample more than 70% of families had monthly income up to a minimum wage, in the economically active population in Brazil 34% of the families had this monthly income (IBGE, 2011). Therefore, it is indispensable to pay attention to the socioeconomic context of the families, in which the parents have low education level, and very little reading and writing. This profile in the familiar environment influences the scholar performance of the students, as they tend to stimulate less and less their children, as shown in several works in literature (Ardila, Rosselli, Matute, & Guajardo, 2005; Hackman & Farah, 2009), which might interfere with the IQ levels of the students.

Deficiencies derived from the public education might also contribute for the low performance in the cognitive processes (Kishiyama, Boyce, Jimenez, Perry, & Knight, 2009). Dal Vesco, Mattos, Beninca and Tarasconi (1998) intended to compare the performance in WISC among students of private and public schools. Twenty students took part in it (10 from public school and 10 from private school), from 5th to 8th grade, with ages between 8.7 and 13.2 years old. The results showed a meaningfully higher punctuation from the private school students in some subtests. The authors discussed the influence of sociocultural determiners on the WISC performance, in special the quality of education in public school, which might also have a little stimulation on the cognitive processes of children and teenagers.

In relation to the association between sleep and the cognitive performance in visuospatial skills, in the present study, the pattern of sleep (early and regular bedtimes) was correlated to the best performance in tasks that evaluated visuospatial skills. Evidences pointed out that sleep accomplishes several functions associated to cognition, as repair and consolidation of learning or memory, besides being responsible for restoring processes, as much in the body as in the human brain (Curcio, Ferrara, & De Gennaro, 2006). Therein, literature points out significant correlation between sleep and a wide set of cognitive processes and domains, sensorial and motor, as individuals who sleep well, in a regular way and with a proper sleep duration have a better utilization in tasks that require the application of cognitive

processes, which are also related to a better performance in scholar activities (Buckhalt, El-Sheikh, & Keller, 2007; Fallone et al., 2005).

As an example, Gruber et al. (2010), in a study with children from 7 to 11 years old, verified that the higher duration of habitual sleep in healthy children was associated to better performance in perceptual reasoning and Full Scale IQ, measured by WISC-IV, and in related measures of competence and academic performance. The data related to sleep duration were obtained through actigraphy and the Sleep Diary. The data related to academic performance were obtained using specific protocol, filled by their parents. Besides, the research of Fallone et al. (2005) found that sleep deprivation of 6.5 hours per night, during three consecutive weeks, had a negative impact on the academic performance of children with age between 6 and 12 years old. The information on sleep of this study were obtained through actigraphy (that register objectively, through an advice used in the wrist, the sleep and awakening times of the individuals), and the performance at school was evaluated through a questionnaire developed by researchers and filled in by the participants professors. Therefore, based on discussions from literature, significant correlations were hoped between visuospatial skills and pattern indicators of the sleep-wake cycle in the present study, even though they were weak.

Regarding the weak correlation found in the present study between the pattern of sleep and visuospatial sills, it cannot be eliminated the possibility that such associations would be correlated to other indicators that affect as sleep as the cognitive performance, such as genetic, somatic and motivational factors. Or even the nature of the subtests used in this research, which are responsible for evaluating many cognitive functions besides visuospatial skills, might cause difficulties in the comprehension of the results. This factor, on the other hand, is one of the limitations of this study.

Another limitation in the study was the size of the sample, as an *N* bigger than 31 could generate stronger data. Possibly, to considerate students from other grades, in the same age group, could minimize this difficulty. As the sample included individuals from both genders, and the literature discusses differences between genders regarding the pattern of the sleep and wake cycle (Klein & Gonçalves, 2008), it would also be interesting that future researches evaluated the sleep variables considering the performance of boys and girls. The same is equivalent to children and teenagers, whose analyses needed to be more related to their peculiarities in sleep ontogenesis.

Difficulties were also observed in the fulfilling of Sleep Diaries. On one side, parents might not register effectively data relative to sleep (as it is about the sleep of the third person), and on the other side there is the impossibility of the children filling it in on her own. It was noted that with instructions and training for fulfilling, even the parents did not answer satisfactorily to the instruments. A possibility to be considered is the use of protocols with less text and more graphic elements of easy understanding, besides the use of actimeters (along with the diaries), instruments of objective measurement in which the data of sleep duration and sleep and awakening times are registered.

Summing up, the results of this study showed regular sleep and with proper duration to the students and that there were significant correlations between the early bedtime and the regular sleep with the performance of visuospatial skills, which means the pattern of proper sleep contributed to a better cognitive performance. Besides, this study verified that losses in the visuospatial skills might be also influenced by social and economic factors associated to the context in which these students are inserted.

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