

Chapter 4 Association between sleep quality and executive functions in a sample of first-semester medical students at a public university

Capítulo 4 Asociación entre la calidad del sueño y funciones ejecutivas de una muestra de alumnos del primer semestre de medicina de una universidad pública

MERAZ-MEDINA, Tzintli†*, HERNÁNDEZ-HERNÁNDEZ, Oscar Eduardo, GARCÍA-ORTIZ, Lidia and CÁRDENAS-VILLALVAZO, Asucena

Universidad de Guadalajara, Science Health Division, University Center of South, Mexico.

ID 1st Author: *Tzintli, Meraz-Medina* / **ORC ID:** 0000-0002-2062-8618, **CVU CONACYT ID:** 131300

ID 1st Co-author: *Lidia, García-Ortiz* / **ORC ID:** 0000-0002-4861-0989, **CVU CONACYT ID:** 260835

ID 2nd Co-author: *Oscar Eduardo, Hernández-Hernández* / **ORC ID:** 0000-0001-6245-0101, **CVU CONACYT ID:** 1008705

ID 3rd Co-author: *Asucena, Cárdenas-Villavalzo* / **ORC ID:** 0000-0003-4910-5906, **CVU CONACYT ID:** 93618

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T. Meraz, O. Hernández, L. García and A. Cárdenas

* tzintli.meraz@cusur.udg.mx

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Abstract

Poor sleep quality is common among medical students, it has been attributed to high demand of medicine careers; meanwhile sleep insufficiency has been associated with lower academic performance. Nevertheless, still not fully understood the processes that underlie such effect, like the alteration of executive functions that could occur due to sleep insufficiency. In this study, were assessed the sleep quality using the Pittsburgh Sleep Quality Index (PSQI) and executive functions using the WisconPC program, in 38 first-semester medical students, the instruments were applied at the beginning and at the end of school cycle and correlations were estimated. The results of PSQI evidenced a sleep quality worsened towards the end of the semester (start: 8.31 ± 3.41 , end: 10.92 ± 1.81), a reduction in the average of sleep hours from 6 to 2.4 at the beginning and end of the semester respectively; however, overall score revealed low sleep quality since the initial evaluation in most of participants. On the other hand, we did not find significant changes in the components of the executive functions; except the correlation between the average reaction time per response and the average reaction time of hits, which indicates the development of cognitive flexibility at the end of semester. No correlation was found between sleep quality and executive functions, further studies are needed to understand the functional relations between sleep and cognitive processes, also to explain the mechanisms underlying the academic performance impairment, attributed to poor sleep. Besides, it is needed to research the etiology of the poor sleep quality that students inform from the beginning as university students, to implement interventions to improve the overall quality of life of medical students, that is reflected in their academic performance.

Quality sleep, Executive functions, Medical students

Resumen

La mala calidad del sueño es común entre los estudiantes de medicina, lo que se ha atribuido a la alta demanda académica de la carrera; a su vez, dormir inadecuadamente se ha asociado a un menor desempeño académico. Sin embargo, aún no se comprenden del todo los procesos que subyacen a tal efecto, como la alteración de funciones ejecutivas que podrían ocurrir debido al sueño insuficiente. En este estudio se evaluaron la calidad del sueño mediante el Índice de calidad de sueño de Pittsburg (ICSP) y las funciones ejecutivas mediante el programa WisconPC; en 38 alumnos de primer semestre de medicina, los instrumentos se aplicaron al inicio y final del ciclo escolar y se buscaron correlaciones entre variables. Los resultados del ICSP evidenciaron un deterioro en la calidad del sueño hacia el final del semestre (inicio: 8.31 ± 3.41 , final: 10.92 ± 1.81), al igual que una reducción del promedio de horas de sueño de 6 a 2.4 al inicio y final del semestre respectivamente; sin embargo, el puntaje general reflejó baja calidad de sueño desde la evaluación inicial en la mayoría de participantes. Por otro lado, no encontramos cambios significativos entre los dos momentos del semestre en los componentes de las funciones ejecutivas; con excepción de la correlación entre el tiempo de reacción promedio por respuesta y el tiempo de reacción promedio de aciertos, lo que indica el desarrollo de flexibilidad cognitiva hacia el final del semestre. No se encontró correlación entre la calidad de sueño y las funciones ejecutivas, es necesario realizar otros estudios que profundicen en las relaciones funcionales del sueño y los procesos cognitivos, y que expliquen los mecanismos de afectación del desempeño académico adjudicados a dormir inadecuadamente. Además, se requiere investigar la etiología de la mala calidad del sueño que los estudiantes reportan desde el inicio de su primer semestre universitario, de manera que se puedan implementar intervenciones para mejorar la calidad de vida general de los estudiantes de medicina, que se refleje en su rendimiento académico.

Calidad del sueño, Funciones ejecutivas, Estudiantes de medicina.

4.1 Introduction

Sleep is a physiological state that consists of sequential and cyclic phases, during each stage vital processes occur; as metabolic and endocrine regulation, and others mechanism to maintain homeostasis. In recent decades, the prevalence of sleep disorders has increased worldwide, as well as sleep insufficiency associated with work or school schedules and demands (D'Ambrosio *et al.*, 2019). The sleep quantity and quality are physical and mental health determinants, with effects on different systems such as the nervous, associated primarily with cognitive functions; currently, the lack of sleep or poor quality has become a major health public problem (Carrillo, Barajas, Sánchez, & Rangel, 2018; Lira & Custodio, 2018). Sleep quality involves quantitative and qualitative aspects such its duration, onset latency, efficiency to achieve rest and restorative effect, daytime dysfunction and sleep disturbances (Krystal & Edinger, 2008).

The sleep insufficiency is usual among university students, they tend to reduce the time spent sleeping in order to achieve their academic goals; particularly in medicine career (García-López & Navarro-Bravo, 2017; Palatty, Fernandes, Suresh & Baliga, 2011; Saad *et al.*, 2016). Nevertheless, it is suggested that poor sleep quality impairs cognitive functions, then academic performance could be affected (Curcio, Ferrara & De Gennaro, 2006; Gomes & Azevedo, 2011; Quevedo-Blasco, R. & Quevedo-Blasco, V. J., 2011; Vecsey *et al.*, 2009). Some authors suggest that first-year students are more vulnerable, due to the changes involved in the transition to university level, which entails irregular sleep patterns, others claim to find differences between advanced school grades (Cheng *et al.*, 2012; Lemma *et al.*, 2012).

The mechanisms underlying the impact on academic performance attributed to poor sleep quality, are still not clear; some researchers suggest it is due to daytime sleepiness and dysfunction (de la Portilla-Maya *et al.*, 2019). Others have shown that sleeping interrupts the damage induced by reactive oxygen species (ROS), produced by the activity inherent to wakefulness. Likewise, sleep facilitates the synthesis and function of molecules that protect nerve cells and glia from oxidative stress and gives time to repair or replace essential cellular components of nerve tissue that were damaged (Siegel, 2005). These protective functions of sleep help maintain cognitive abilities essential for learning, whose efficiency could be reflected in student academic performance, reaffirming the importance of well sleeping (Benavides-Endaras & Ramos, 2019).

On the other hand, sleep quality could influence the cognitive brain processes that underlie academic performance, as the ability to assimilate new knowledge through attention, comprehension, memory, and executive functions, which can be altered (Jiménez-Puig, Broche-Pérez, Hernández-Caro & Díaz-Falcón, 2019). These functions are cognitive abilities that allow transforming thoughts and emotions into actions, it include four domains: attentional control, information processing, goal setting, and cognitive flexibility (Anderson, 2002; Lezak, Howieson, & Loring, 2004); in wich, memory is implicit. Memory is the ability to encode, store and retrieve information and it is essential in all cognitive processes. The role of sleep-in memory consolidation has generated controversy and research continues to elucidate it (Siegel, 2001; Wamsley, Tucker, Payne & Stickgold, 2010), in that regard, has been shown sleep to facilitate neurogenesis in the dentate gyrus of hippocampus (Siegel, 2005 Op. cit), being already known the hippocampus role in memory processes. Executive functions are essential to carry out learning processes as well to plan and achieve objectives set by the students. Nevertheless the sleep rol in academic performance is still unclear, so more specific research about underlying cognitive processes is needed.

Nevertheless there are no regional or local epidemiological studies, to allow us to know the situation of sleep problems of student population, even less about the causal relations of poor sleep quality or sleep insufficiency on executive functions. More research is needed to implement specific strategies to improve the students sleep, health and academic performance. This study was carried out to evaluate the sleep quality by use the Pittsburgh Sleep Quality Index (PSQI), of first semester students of medicine career of the University Center of the South, and its associations with their executive functions through a computerized version of WCST instrument (WisconPC), this program was developed by the Institute of Neurosciences, of the Guadalajara University in México (Guevara, Aguilar & Hernández, 2017). WisconPC allows us to standardize the test application, faster qualification and adjusting to the needs imposed by COVID-19.

4.2 Methods

4.2.1 Study Design and Participants

The study was quantitative, because the level of analysis was considered descriptive, correlational, cross-sectional, non-experimental. The study was conducted during the period from August to December 2021, the population was taken as first semester students of the midwife surgeon medical career (MCP) of the public University in the South of Jalisco, Mexico.

The sample was calculated with a 95% confidence interval (CI), expected error of 5%, $n=38$, the sampling was probabilistic by clusters, the inclusion criteria considered were first semester MCP students who agreed to participate, the sociodemographic variables measured were: sex, age, whether they live with their parents or not, with whom they share a room, whether they work or not. The study variables considered were sleep quality as an independent variable and executive functions as a dependent variable.

4.2.2 Instruments

Two instruments were used: the first called the Pittsburgh Sleep Quality Index (PSQI), which consists of 19 items self-assessed by the patient. They are grouped into 7 sleep components: quality, latency, duration, efficiency, disturbances, use of sleep medication and daytime dysfunction. Each component is scored from 0 to 3. The sum of the 7 components gives the total score of the PSQI, which ranges from 0 to 21 points (the higher score means the worse quality of sleep). The Pittsburgh index: Buysse et al. 1989 found an internal consistency for the 19 items of 0.83 Cronbach's alpha, consisting of two factors: sleep quality per se and sleep duration.

The second instrument used was the WisConPC test, which evaluates executive functions in 4 domains: attentional control, information processing, cognitive flexibility, and goal setting. The test consists of the presentation of four sample cards (pattern cards), together with a block of 128 stimulus (response) cards. The application time is 15 to 20 minutes. The test allows us to know: total number of stimuli (response cards) presented, total and percentage of correct and incorrect responses, total perseverations, completed sequences, total average reaction time (RT), average RT of correct responses and average RT of incorrect responses. The Wisconsin test, has been used extensively in research and clinical settings to measure executive functions, proving to be highly reliable (Drewe, 1974).

The procedure was developed in two stages, one >pre<, two weeks after the beginning of the semester, with the objective that the students had a period of adaptation to the entrance to the university in its virtual modality; and an application in a >post< stage, 15 days before the end of the semester, to avoid acquiescence due to the workload and final exams.

An online survey with 19 items was applied to collect information on the sociodemographic status of the students. The link to access the Google Forms platform where the survey was located was shared with the students by email, and the survey began with informed consent, in case the student did not wish to participate, the form thanked him/her and did not require more information. In case the student decided to participate, the form displayed the sociodemographic survey and the Pittsburgh test for them to answer. The results were added to an individual folder with the student's name on the Google Drive platform, which only the participant and the researchers could access (data protection). At the end of the study, participants were able to review the results of the tests that were applied to them in the research, which allowed them to know their quality of sleep and their performance in executive functions.

4.2.3 Ethical Considerations

The present research work is based on the Regulations of the General Health Law on research, taking as a basis the following articles: article 16 to protect the privacy of the individual, article 17 was considered a research with risk minimum because it answered psychological tests, article 57 was also considered where the informed consent was influenced by some authority, in this case the present study was authorized by the Ethics Committee of the University Center, with folio CEI/045/2021. The application of the principles of the Declaration of Helsinki (beneficence, respect for human dignity and justice) of the World Medical Association for Medical Research Involving Human Subjects was considered for the development of the study.

4.2.4 Statistical analysis

The statistical analysis was correlational between quantitative variables, descriptive and dispersion data are reported, and a normality test was performed to verify the distribution of the data. It was determined that both the Pittsburgh sleep quality index and the Wisconsin test do not have normal distributions, the Kolmogorov-Smirnov test yields a significance level (95%) less than 0.05, so there are no normal data, so the Wilcoxon test was performed, this was applied for both tests. To determine the strength of correlation between variables, Spearman's correlation coefficient test was used. The statistical tool Statistical Package for the Social Sciences v. 25.0 (SPSS) in Spanish and freely available was used for data processing.

4.3 Results

4.3.1 Sociodemographic information

In the present study, 100% of the participants were medical students, most of them were female (63%). Of the total number of students, a high percentage still lived with their parents (73%) and did not work (71%), according to the sociodemographic data shown in Table 4.1.

Table 4.1 Sociodemographic data

Variable		Frequency
Age		18.21 (DE=.41)
Sex	Women	n = 24 (63%)
	Men	n = 14 (37%)
Studying		Medical student
With whom do you currently live?		Nuclear family (parents and siblings)
		Others
With whom do you currently share a room?	Friend/Partner	n = 3 (8%)
	Family	n = 10 (27%)
	I do not share	n = 25 (65%)
Are you currently working?	Weekends	n = 9 (24%)
	Half time	n = 2 (5%)
	I do not work	n = 27 (71%)
Notes: n (%) = Frequency (percentage).		

Source: Own elaboration

Of all participants, 60% or more rated their sleep quality, sleep latency and sleep efficiency at the beginning of the semester as good and fairly good; they reported sleeping between 6 and 7 hours. On the other hand, at the end of the semester, 50% of students reported poor and fairly poor sleep quality, while the time spent sleeping was reported to be less than 6 hours, and the percentage with very poor sleep efficiency increased. Sleep disturbance and use of medication for sleep showed similar percentages at both times of the study; however, an increase was perceived at the end of the semester, 11% have problems with daytime dysfunction more than 3 times per week and 20% once or twice per week. At the beginning of the semester 78.94% of the students resulted as poor sleepers, towards the end of the semester 100% were categorized as that, it can be seen in Table 4.2.

Table 4.2 Sleep quality of medical students at the beginning and end of the semester

Component	Scale	Beginning of semester		End of semester	
		N	%	N	%
Sleep quality	Very good	7	18%	0	0%
	Fairly good	16	42%	18	47%
	Fairly bad	0	0%	12	32%
	Very bad	14	37%	7	18%
Latency	Very good	14	37%	16	42%
	Fairly good	11	29%	12	32%
	Fairly bad	11	29%	3	8%
	Very bad	1	3%	0	0%
Sleep duration	> 7 hours	6	16%	0	0%
	6-7 hours	14	37%	6	16%
	5-6 hours	18	47%	10	26%
	< 5 hours	0	0%	22	58%
Sleep efficiency	>85%	14	37%	0	0%
	75-84%	12	32%	13	34%
	65-74%	6	16%	0	0%
	< 65%	6	16%	25	66%
Sleep disturbance	Not during past month	5	13%	14	37%
	Less than once a week	23	61%	13	34%
	Once or twice a week	7	18%	9	24%
	Three or more times a week	2	5%	2	5%
Use of sleep medication	Not during past month	25	66%	21	55%
	Less than once a week	13	34%	12	32%
	Once or twice a week	0	0%	5	13%
	Three or more times a week	0	0%	0	0%
Daytime dysfunction	Not during past month	3	8%	1	3%
	Less than once a week	12	32%	6	16%
	Once or twice a week	11	29%	20	53%
	Three or more times a week	12	32%	11	29%
Global PSQI score	Good sleepers	8	21.05%	0	0%
	Bad sleepers	30	78.94%	38	100%
Average sleeping hours per day at the beginning of semester	6.05				
Average sleeping hours per day at the end of semester	2.42				

Source: Own elaboration

4.3.2 Comparisons of sleep quality between the beginning and end of semester period in medical students

There are statistically significant changes between pre-assessment and post-assessment. At the beginning of the semester the duration component scores were 1.32 ± 0.73 , while at the end of the semester they were 2.42 ± 0.75 . The efficiency component scores were 1.11 ± 1.08 and 2.32 ± 0.96 respectively. The increased scores indicate that sleep duration and efficiency was poor at the end of the semester. The total PSQI score showed statistically significant changes in the score at the beginning of the semester 8.31 ± 3.41 compared to that at the end of the semester 10.92 ± 1.81 , comparisons are shown in the total score, the score increased between the pre evaluation and post evaluation, which translates into sleep problems; however, it is necessary to take into account that from the beginning of the semester the students presented an overall score higher than 5, which places them as poor sleepers or with sleep problems. (Table 4.3)

Table 4.3 Wilcoxon t-test to compare the score of the 7 components of the Pittsburg sleep quality index

Component	Beginning of semester	End of semester	P
Sleep quality	1.55 (1.17)	1.71 (.76)	.56
Sleep Latency	1 (.90)	.84 (.82)	.36
Sleep duration	1.32 (.73)	2.42 (.75)	.001
Sleep efficiency	1.11 (1.08)	2.32 (.96)	.001
Sleep disturbance	1.16 (.71)	.97 (.94)	.301
Use of sleep medication	.34 (.48)	.58 (.72)	.060
Daytime dysfunction	1.84 (.97)	2.08 (.74)	.231
Global PSQI score	8.31 (3.41)	10.92 (1.81)	.001
Notes: X: media; SD: Standard deviation			

Source: Own elaboration

4.3.3 WisconPC test: initial and final semester results

The results of the WisconPC test showed no significant changes between the initial and final application, only the variable of average time of correct answers showed a significant difference, indicating that students took less time to answer correctly in the test applied at the end of the semester. The results are shown in Table 4.4.

Table 4.4 Wilcoxon test to compare the score of the WisconsinPC test

Component	Beginning of semester	End of semester	p
Total number of correct responses	48.89 (7.10)	50 (6.53)	.631
Average hit time	2.41 (1.26)	1.83 (.44)	.042
Total numbers of errors	2.40 (.86)	2.21 (.81)	.261
Average per response (seconds)	2.30 (.95)	1.97 (.60)	.115
Total of perseverations	7.26 (4.64)	5.94 (3.02)	.216
Notes: X: media; SD: Standard deviation			

Source: Own elaboration

4.3.4 Correlation between Sleep Quality Index scores and Wisconsin test results

Correlation was performed between the total score of the PSQI, executive functions and hours of sleep, another one between all the components of the PSQI and the components of the Wisconsin test. Correlations were performed using Spearman's test, from which it was determined that there is no correlation between the variables of the total score of the PSQI and executive functions, in addition to hours of sleep and executive functions.

Graphic 4.1 shows the correlation between the PSQI components and the Wisconsin test components (lower left gray box), correlation between the PSQI components (upper green triangle) and correlation between the Wisconsin test components (lower orange triangle).

Graphic 4.1 Spearman correlation between the components of the Pittsburg sleep quality index and the Wisconsin components

	C	L	D	E	A	UDM	DD	NDA	TPA	TPE	PPR	TP
C	1											
L	.05	1										
D	.40*	-.02	1									
E	-.20	-.07	-.33*	1								
A	-.01	.42*	.01	-.39	1							
UDM	-.27	-.06	.08	.11	-.18	1						
DD	.08	.02	.08	-.37	-.03	-.18	1					
NDA	.17	-.14	-.10	-.13	-.09	.21	.02	1				
TPA	.02	-.07	.26	.06	.140	-.03	-.06	-.30	1			
TPE	.02	.01	.31	.09	.13	.22	-.20	-.20	.68*	1		
TPR	-.07	.14	.19	.14	.01	-.05	-.09	-.35*	.86**	.56**	1	
TP	.07	.13	-.07	-.16	.25	-.17	-.12	-.27	-.09	-.27	.80	1

Source: Own elaboration

Note: Quality (C), Latency (L), Duration (D), Efficiency (E), Alterations (A), Use of sleep medication (UDM), Daytime dysfunction (DD), Number of hits (NDA), Average reaction time of hits (TPA), Average reaction time of errors (TPE), Average reaction time per response. (TPR), Total perseverations (TP). *** $p < .001$, ** $p < .01$, * $p < .05$.

The correlation between the components of the Wisconsin test showed that the greater the average reaction time per response, the greater the average reaction time for successes ($r = .86$, $p < .01$), and the greater the average reaction time for errors, the greater the average reaction time for successes ($r = .68$, $p < .05$). Finally, we observed that the greater the total average reaction time, the greater the average reaction time for errors ($r = .56$, $p < .01$).

4.4 Discussion

Sleep is an essential part of human health and life; this action has been related to different cognitive functions. It is well documented, that lack of sleep or poor sleep quality affects individual learning ability, academic performance and performance of neurocognitive functions (Gutiérrez-Ruiz *et al.*, 2020; Jalali *et al.*, 2020; Granados-Carrasco *et al.*, 2013). This study aimed to determine the relationship between sleep quality and executive functions in first semester medical students at a public university in Jalisco.

Multiple studies have been conducted on sleep quality and various cognitive functions in medical students, especially in those who are in their last year of study and in those who are in a medical residency specialty, however, little attention has been paid to first semester or first year students according to the university program. This population is especially susceptible to sleep disturbances due to the change that represents the transition from high school student to university demands, even more so in a career that historically, has been characterized by its high academic demand (Baars *et al.*, 2015; Knouse, Feldman, & Blevins, 2014).

It is important to mention that the study was planned to be carried out in a normal university environment; however, the arrival of the COVID-19 pandemic forced the universities to migrate to virtuality, making it necessary to adapt and apply the survey and tests virtually. The fact that the subjects were taught virtually for the first time resulted in a decrease in the academic demands of the professors, since most had to adapt their syllabus to virtuality in a matter of days, so that many of the practices, exams and assignments were excluded, thus reducing the academic load, even so distance education represented a challenge for the students.

At the beginning of the semester students slept on average more than 6 hours a day, however according to the PSQI score the highest percentage was classified as poor sleepers, while at the end of the semester 100% of the students were classified as poor sleepers with an average of 2.4 hours of sleep per day, in addition significant changes were observed in the duration and efficiency of the hours of sleep. These results are not surprising since, as mentioned above, despite the changes that occurred in the academic load due to the change to virtuality, the academic demand continues to be high (Rao *et al.*, 2020; Jalali *et al.*, 2020 Op. cit).

Meta-analyses and systematic reviews have concluded that sleep quality and duration have an association on academic performance (Dewald *et al.*, 2010; Shochat, Cohen-Zion & Tzischinsky, 2014), however, there are no conclusive results about the impact of sleep duration and efficiency on learning and academic performance (Hershner & Chervin, 2014; Taras & Potts-Datema, 2005; Gruber *et al.*, 2010). In this sense, there is a possibility of sleep disturbance in students, and this possibility is expressed as lack of academic performance, however, this relationship has not been clearly explained (Gaultney *et al.*, 2010).

Cognitive processes are determinants of academic performance; executive functions are cognitive variables that play an important role in the development and maintenance of academic skills. The WisconPC test allowed us to know the predominant domains such as working memory and cognitive flexibility.

Through Wilcoxon test it was possible to identify changes in the executive functions between the two times of the study, the most outstanding was the improvement in cognitive flexibility, since the students had more correct answers, the average reaction time per answer was directly proportional to the average reaction time for correct answers and for errors, which makes us suppose that the decrease in the rest time caused the students to be slower when performing the test, however the number of correct answers was higher. The increase in the number of correct answers is logical since, as the subject has more correct answers, it is easier to identify the different categories proposed by the task (Ramírez-Flores & Ostrosky, 2012), reinforcing the assumption of improvement in cognitive flexibility.

In the present study we found no significant correlations between the components of the Pittsburgh Sleep Quality Index and the components of the Wisconsin test, leading us to conclude that good sleep has no impact on executive functions and probably on academic performance.

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4.6 Founding

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4.7 Conclusions

The academic load in first semester medical students reduces the time allocated to sleep and reduces the efficiency and duration of sleep resulting in students with sleep problems or "bad sleepers"; however, sleep problems have not been associated with executive functions processes that may have implications on academic performance of first semester medical students.

The results presented highlight the need to explore other cognitive, behavioral and psychological variables that could influence sleep quality and cognitive functions related to overall academic performance, with the aim of developing a multivariate model that allows designing intervention programs that promote the well-being of the student community.

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