Sleep quantity, quality, and insomnia symptoms of medical students during clinical years

Relationship with stress and academic performance

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ABSTRACT

الأهداف: تحديد عادات النوم والاستيقاظ لدى عينة من طلبة الطب في السنوات الإكلينيكة، وتحديد مدى انتشار النوم رديء الجودة، فرط النعاس أثناء النهار، أعراض الأرق، وظاهرة الاستيقاظ طوال الليل والنوم خلال النهار لديهم. بالإضافة إلى ذلك سعينا إلى تحديد دور الضغط النفسي ومستوى التحصيل الدراسي في هذه الظواهر، بالإضافة إلى عوامل أخرى.

الطريقة: أُجريت هذه الدراسة على عينة عشوائية اختيرت من قائمة الطلاب والطالبات المسجلين في كلية الطب في السنوات الاكلينيكية (السنة الرابعة والخامسة والسادسة)، وعددهم 320 طالباً (2011-2012). قام الطلبة بتعبئة استبيان يتضمن مؤشر بيتسبورغ لتحديد جودة النوم، مقياس ايبوورث لتحديد مدى فرط النعاس خلال النهار، ومقياس الضغط النفسي، بالإضافة إلى معلومات ديموغرافية ومعلومات عن نمط الحياة.

النتائج: أظهرت الدراسة أن متوسط معدل ساعات النوم الليلي لدى الطلبة هو 5 ساعات و50 دقيقة، وأن متوسط موعد الخلود للنوم في كل ليلة من ليالي الأسبوع هو الساعة 1:53 صباحاً. بالإضافة إلى ذلك، تبين أن 8% من الطلبة يعانون من انقلاب تام في الساعة الحيوية (بمعنى أنهم يظلون مستيقظون طوال الليل ويخلدون إلى النوم بعد العودة من الجامعة بصفة يومية). كما أظهرت النتائج أن 30% من الطلبة يعانون من رداءة جودة النوم، و40% يعانون من فرط مستوى النعاس أثناء النهار، و33% يعانون من أعراض الأرق. عند تحليل علاقة الضغط النفسي ومستوى التحصيل الدراسي بالنوم، أظهرت الدراسة أن الطلبة الذين يعانون من ضغط نفسي عالي أكثر عرضة بكثير لرداءة مستوى جودة النوم وفرط النعاس أثناء النهار. وأن مستوى التحصيل الدراسي المتدني والضغط النفسي مرتبطان بأعراض الأرق الليلي.

الخاتمة: تظهر هذه الدراسة أن ظواهر الحرمان من النوم الكافي، ورداءة جودة النوم، وفرط النعاس أثناء النهار منتشرة بين طلبة الطب في المرحلة الإكلينيكية. قد يلعب ارتفاع نسبة الضغط النفسي ومحاولة التفوق الدراسي على حساب النوم دور في وجود هذه الظواهر.

Objectives: To determine sleep habits and sleep quality in medical students during their clinical years using validated measures; and to investigate associations with academic performance and psychological stress.

Methods: In this cross-sectional study, medical students (n=320) were randomly selected from a list of all enrolled clinical-year students in a Saudi medical school from 2011-2012. Students filled a questionnaire including demographic and lifestyle factors, Pittsburgh Sleep Quality Index, Epworth Sleepiness Scale, and Perceived Stress Scale.

Results: Students acquired on average, 5.8 hours of sleep each night, with an average bedtime at 01:53. Approximately 8% reported acquiring sleep during the day, and not during nighttime. Poor sleep quality was present in 30%, excessive daytime sleepiness (EDS) in 40%, and insomnia symptoms in 33% of students. Multivariable regression models revealed significant associations between stress, poor sleep quality, and EDS. Poorer academic performance and stress were associated with symptoms of insomnia.

Conclusion: Sleep deprivation, poor sleep quality, and EDS are common among clinical years medical students. High levels of stress and the pressure of maintaining grade point averages may be influencing their quality of sleep.

The crucial role of sleep in maintaining mental health, high-level learning, and general wellbeing has received considerable attention over the past decade.[1-5] Medical students are considered a population that is particularly prone to sleep-related problems. Studies from various countries have documented a high prevalence of sleep disturbances among medical students, including sleep deprivation,[6] poor sleep quality,[6-8] and excessive daytime sleepiness (EDS).[8] Several factors have been investigated as being caused by, or being risk factors for, sleep disturbances. Among medical students, high levels of stress have been associated with sleep problems.[9,10] This association is particularly important due to the high prevalence of stress in this student population. A systematic review of 40 studies from Canada and the United States showed a consistently higher level of psychological distress among medical students compared with the general population.[9] High levels of emotional exhaustion have also been associated with sleep problems. However, the relationship may be reciprocal. A recent study[10] on burnout and sleep problems in medical students showed that higher levels of emotional exhaustion and EDS influenced each other. The academic performance of medical students seems to influence and be influenced by sleep. In a qualitative study that addressed factors that determine the academic achievement of medical students, students identified the management of sleep deprivation as crucial for academic success.[11] Hours of sleep acquired before exam time has been identified as a predictor of exam scores among medical students.[12] Similarly, poor sleep quality before exams has been shown to correlate with worse academic achievement.[13] The effect of poor sleep on cognitive and psychomotor performance may underlie these associations.[14,15] For example, a meta-analysis of 24 studies showed that adults diagnosed with insomnia exhibited higher levels of cognitive function impairments in memory compared with those without insomonia.[15] Moreover, the psychomotor performance of medical students, particularly in judgement ability, has been shown to worsen with 24 hours of sleep deprivation.[14] Although studies have investigated the associations among sleep, stress and academic performance in medical students, many of those studies look at stress and academic performance as the outcome. However, it is reasonable to argue that

medical students are subject to high levels of stress and work hard to increase and maintain their grade point average (GPA) at the expense of sleep. In addition, most of these studies examined only one or 2 sleep measures. In the current study, we aimed to investigate 4 aspects of sleep, namely, sleep quantity, sleep quality, insomnia, and EDS as outcomes, and to determine how they relate to stress levels and academic performance in the same cohort of medical students, thereby eliminating many potential differences introduced by comparing these outcomes between studies. Moreover, a pattern of predominant daytime sleeping during week days, as opposed to sleeping during nighttime (namely, staying up all night, and sleeping after returning from university) was documented in a previous study of high school students in Jeddah, Kingdom of Saudi Arabia (KSA).[16] This pattern does not fit any of the circadian rhythm sleep-wake disorders classified by the International Classification of Sleep Disorders (ICSD-3).[17] Therefore, we aimed to investigate the prevalence of such sleep habits among medical students. The aims of the current study were: 1) to describe the sleep-wake habits of medical students in one of KSA's largest universities; 2) to determine the prevalence of a predominant daytime sleeping pattern among medical students and its association with academic performance and stress levels; and 3) to determine the prevalence of poor sleep quality, EDS, and insomnia symptoms and their association with academic performance and stress level among other demographic and lifestyle factors.

Methods. *Study design and participants.* This cross-sectional study recruited medical students who were enrolled in the Faculty of Medicine, King Abdulaziz University (KAU), Jeddah, KSA. Students who were eligible for the study are those who were registered for their fourth, fifth, or sixth year (namely, students in their clinical years) during the 2011-2012 academic year. A list of all students registered was obtained from the Faculty of Medicine's Academic Affairs, and a random sample of 320 students was selected from this list. The questionnaire was administered in English language and completed by 305 students, resulting in a response rate of 95%. To put the study results in perspective to an international audience, it is important to mention that clinical years students in Saudi medical schools attend clinical sessions and lectures, which mostly take place in the early morning up until the early afternoon. They are not expected to be on call during their clinical years, nor are they obligated to actively participate in all clinical care beyond their teaching sessions. Being part of a

medical team and being on call is expected of students in their obligatory internship year (namely, seventh year). Interns are not typically viewed as students and are not part of this study population.

Questionnaire administration and ethics. Four trained physicians administered the questionnaire. A workshop was held by the corresponding author to train them on administering the questionnaire and answering questions from participants. A pilot study was conducted, in which the questionnaire was pretested on a sample of 10 students to test the data-gathering mechanism, and to assess the legibility, practicality, and reliability of the questionnaire. Students were informed that their participation was voluntary and their responses were confidential. Ethical approval was granted by the Ethical Committee at the Faculty of Medicine, KAU, Jeddah, KSA.

Variables. The questionnaire collected the following information: 1) Demographic and lifestyle factors, including age, gender, academic performance, daily caffeine intake (including coffee, tea, and caffeinated sodas), and napping habits; 2) The Pittsburgh Sleep Quality Index (PSQI) to assess sleep-wake patterns and sleep disturbance; 3) The Epworth Sleepiness Scale (ESS) to assess daytime sleepiness; and 4) The Perceived Stress Scale (PSS-10) to assess psychological distress.

Sleep-wake habits. Weeknights and weekend sleep and rise time, sleep latency and sleep duration. The Pittsburgh Sleep Quality Index (PSQI) is a standardised, reliable, and valid scale that is used to measure the quality and patterns of sleep in adults.[18] The PSQI includes 19 self-rated questions regarding sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances and insomnia, use of sleep medication, and daytime dysfunction during the previous month. The first 4 questions inquire regarding typical bedtime, rise time, sleep latency, and the hours of sleep acquired each night, also called total sleep time (TST). Students filled in their answers and we include them as continuous variables in our analysis.

Sleep quality. Following the questions inquiring regarding sleep-wake habits, the PSQI asks 15 questions on the components of disturbed sleep and perceived quality of sleep.[18] To assess sleep quality, we used answers to a question regarding students' perceived quality of sleep during the previous month. The response choices for this item were as follows: very poor, fairly poor, fairly good, or very good. Sleep quality was dichotomized into normal sleep (answered fairly good or very good), and poor sleep (answered fairly poor or very poor). Although the PSQI instrument also assesses a global

measure of sleep disturbance as a sum of answers to all its sub-components, in the current study, we detangled the sub-components to analyze the question inquiring regarding self-reported sleep quality, and those inquiring regarding insomnia symptoms, separately.

Excessive daytime sleepiness. The Epworth sleepiness scale is a valid and reliable instrument that is used to assess subjective daytime sleepiness.[19] Individuals are asked to rate, on a 4-point scale from 0-3 (0= would never doze, 1= slight chance of dozing, 2= moderate chance of dozing, and 3= high chance of dozing), their chance of dozing off or falling asleep in 8 different situations, or activities of daily living. The sum of all 8 items produces a score (between 0 and 24) that reflects average sleep propensity. A score of 10 or more reveals abnormal daytime sleepiness. Therefore, students with an ESS score ≥10 were considered to have EDS, and those with an ESS score <10 were considered not to have EDS.

Insomnia symptoms. In the current study, insomnia symptoms were defined as the inability to sleep within 30 minutes (3 or more times/week), frequent awakenings at night (3 or more times/week), or insufficient sleep (sleeping less than 8 hours/night). To determine the presence of these symptoms, we used questions from the PSQI[18] inquiring on the frequency that the respondent had difficulty falling asleep, and the frequency of waking up during the night, or too early in the morning. For each component, they responded by choosing one of the following categories: not during the past month, less than once a week, once or twice a week, or 3 or more times a week. Students who answered '3 or more times per week' to the previous 2 questions were considered to have symptoms congruent with insomnia. To determine insufficient sleep, the continuous variable reflecting hours of sleep each night was dichotomized into 'sufficient sleep' (sleeping ≥8 hours/night) and 'insufficient sleep' (sleeping <8 hours/night).

Daytime versus nighttime sleepers. Students were classified into daytime or nighttime sleepers based on their answer to the question in the PSQI,[18] inquiring on the usual time they went to bed each night during the previous month. Similar to the categorization reported in a previous study investigating this phenomenon,[16] students were classified into "daytime sleepers", if they had an average bedtime between 07:00 and 20:59 during the previous month, and "nighttime sleepers" if they slept between 21:00 and 06:59.

Perceived psychological stress. Perceived stress was analyzed as an independent variable in the current study. The PSS is a valid, reliable, and widely used psychological

and psychiatric tool that measures a person's perception of stress during the previous month.[20] The current study used the 10-question version of the PSS-10. The students rated their emotional and cognitive responses to specific circumstances in their daily lives on a 5-point Likert scale, ranging from 0-4 (0= never, 1= almost never, 2= sometimes, 3= fairly often, and 4= very often). The maximum score of the scale is 40, and higher scores reflect higher levels of stress and a greater likelihood that stress interferes with the students' health. Students' stress levels were classified into the following 3 categories: low stress (PSS score <12), average stress (PSS score 12-15), and high stress (PSS score >15).

Academic performance. Academic performance was also analyzed as an independent variable in the current study. Academic performance was measured as participants' self-reported academic performance in the previous year and classified into the following 3 categories: Excellent (GPA 4/5-5/5), very good (GPA=3.5/5-3.9/5), and good or below (GPA <3.5/5).

Statistical analysis. The data were described using means ± standard deviations for continuous variables and counts and percentages for categorical variables. The associations between academic performance and stress levels and sleep-wake patterns (weeknight TST, sleep latency (time to fall asleep), weekday rise time, weeknight bedtime, weekend bedtime, and weekend rise time) were analyzed using one-way analysis of variance (ANOVA). If a statistically significant difference was found between groups using one-way ANOVA, Tukey post-hoc tests were used to determine which groups differed from each other. To compare the sleep-wake patterns, demographic variables, and lifestyle variables (including academic performance and stress levels) of daytime and nighttime sleepers, independent t-tests and one-way ANOVA were used. Tukey post-hoc tests were used if significant differences were found between groups using the one-way ANOVA.

Logistic regression models were used to determine the factors that have significant associations with poor sleep quality, EDS, and insomnia symptoms. Stress level, academic performance, as well as demographic variables (gender, age, and grade), and lifestyle variables (napping, caffeine intake, hypnotic medication use, and sleep cycle [daytime/nighttime sleeper]) were included in the models. The significance level for the removal of variables from the model was 0.1, otherwise the significance level was set at 0.05. STATA version 13 (StataCorp., College Station, Texas, USA) was used to analyze the data.

Results. *Characteristics of the study population.* Table 1 presents the characteristics of the study population. The total number of participants was 305 students, aged 20-29 years old (22 ± 1.3), and 58% of the participants were female. Regarding grade level, 44% of the students were in their fourth year, 23% in their fifth year, and 33% in their sixth year. More than half of the students reported good academic performance in the previous year, whereas 25% had excellent, and 15% good or below academic performance. The mean PSS score was 17.4 ± 5.4, and approximately 65% of students were found to have high stress. Napping during the day was prevalent, as approximately 60% of the students reported napping "sometimes" and approximately 23% reported napping "every day". A high percentage of students (65%) drank between 1-2 caffeinated beverages during the day, and approximately 13% drank 3 or more caffeinated beverages. Most students (91%) reported not having used any hypnotic medication to help them fall asleep during the previous month. Of the 9% who reported using hypnotic medication, most (85%) used them less than once per week. Approximately 8% of the students had a reversed sleep cycle (daytime sleepers) during the previous month.

Table 1 - Characteristics of the study population of medical students during clinical years (n=305).

Characteristics	Frequency	%
Gender (n=305)		
Male	127	(42)
Female	178	(58)
Grade (n=305)		
Fourth	133	(44)
Fifth	70	(23)
Sixth	102	(33)
Academic performance (GPA) (n=305)		
Excellent	76	(25)
Very good	184	(60)
Good or below	45	(15)
Stress level (n=305)		
Low	43	(14)
Average	64	(21)
High	198	(65)
Napping (n=299)		
No	50	(17)
Yes, sometimes	181	(60)
Yes, everyday	68	(23)
Caffeine intake per day (n=298)		
No	66	(22)
1-2 cups	193	(65)
3 or more cups	39	(13)
Hypnotic medication use (n=305)		
No	278	(91)
Yes	27	(9)
Sleep cycle (n=272)		
Nighttime sleeper	249	(92)
Daytime sleeper	23	(8)
GPA - grade point average		

Sleep-wake patterns by academic performance and stress levels. The sleep-wake patterns of the overall sample of students are described in **Table 2**. The average total hours of sleep per night was 5.8 ± 2, and sleep latency (time to fall asleep) ranged from 0-360 minutes. Not presented in the table is a comparison between male and female students, in which we have found that male students went to bed at a significantly later hour (03:11) during the weekends than female students (02:16), (*p*=0.001). **Table 2** also presents students' sleep-wake patterns according to stress level and academic performance. Students with excellent, very good, and good or below academic performances showed similar patterns of total hours of sleep, sleep latency, weeknight bedtime, weekend bedtime, and weekend rise time. However, students with excellent

academic performance had a significantly earlier rise time during the week compared with those with good or below academic performance (*p*=0.010). There were no significant differences in the weekday and weekend sleep-wake habits between students with low, average, and high stress levels.

Prevalence of a predominant daytime sleep schedule and characteristics of daytime sleepers. Approximately 8% of students reported going to bed at an hour between 07:00 and 20:59 during the previous month. **Table 3** presents a comparison between daytime and nighttime sleepers' sleep-wake habits, academic performance, and stress levels. Daytime sleepers went to bed on average at 13:05 in the afternoon each day and awoke at approximately 18:40 in the evening (namely, reflecting a pattern of staying awake all night and sleeping after

Table 2 - Sleep-wake patterns of medical students during clinical years; overall, by academic performance and stress levels. (n=305)

Variables	Total sleep time		Sleep latency		Weeknight bedtime		Weekday rise time		Weekend bedtime		Weekend rise time	
	Hours	*P*-value	Minutes	*P*-value		*P*-value		*P*-value		*P*-value		*P*-value
Overall sample	5.8 ± 2	---	31 ± 44	---	1:53 ± 3:51	---	7:08 ± 1:45	---	2:38 ± 2:20	---	11:14 ± 2:40	---
Academic performance												
Excellent	5.4 ± 2	0.113	34 ± 56	0.132	1:36 ± 3:47	0.790	6:36 ± 1:45	0.010*	2:31 ± 2:42	0.492	10:54 ± 2:46	0.373
Very good	5.9 ± 1.9		28 ± 30		1:58 ± 3:58		7:14 ± 1:33		2:34 ± 2:15		11:15 ± 2:28	
Good or below	6.0 ± 1.8		42 ± 59		2:00 ± 3:25		7:32 ± 2:17		3:00 ± 1:58		11:40 ± 2:35	
Stress level												
Low	6.1 ± 2.0	0.502	32 ± 60	0.857	2:15 ± 4:18	0.401	7:31 ± 1:31	0.080	2:49 ± 2:37	0.288	11:00 ± 2:47	0.303
Average	5.9 ± 2.0		29 ± 39		1:18 ± 3:34		6:45 ± 1:25		2:12 ± 2:38		10:49 ± 2:46	
High	5.7 ± 1.9		32 ± 40		2:00 ± 3:50		7:10 ± 1:52		2:43 ± 2:10		11:25 ± 2:36	

Values are expressed as mean ± standard deviation (SD), post-hoc test: excellent, <good, or below, comparisons of sleep-wake patterns between academic performance groups and stress levels were based on one-way analysis of variance (Tukey HSD[honest significant difference] post-hoc test). Weeknight bedtime, weekday rise time, weekend bedtime, and weekend rise time are presented as mean: hour: minutes ± SD (hour: minutes).

Table 3 - Comparison between daytime and nighttime sleepers in sleep-wake patterns, academic performance, and stress level.

Sleep-related outcomes	Daytime sleepers, n=23	Nighttime sleepers, n=249	*P*-value
Sleep-wake patterns*, Mean ± SD			
Total sleep time, hour	5.8 ± 2.5	5.7 ± 1.8	0.031*
Sleep latency, minutes	29 ± 36	32 ± 46	0.143
Weeknight bedtime, hour	13:05 ± 03:20	00:51 ± 01:35	<0.001*
Weekday rise time, hour	18:36 ± 03:03	07:11 ± 01:34	<0.001*
Weekend bedtime, hour	03:36 ± 03:48	02:30 ± 02:07	0.042*
Weekend rise time, hour	12:21 ± 03:49	11:05 ± 02:30	0.006*
Academic performance, n (%)			
Excellent	4 (6)	62 (94)	0.700
Very good	15 (9)	152 (91)	
Good or below	4 (10)	35 (90)	
Stress level, n (%)			
Low	7 (17)	34 (83)	0.099
Average	4 (7)	53 (93)	
High	12 (7)	162 (93)	

SD - standard deviation, *Comparisons of sleep-wake patterns between daytime and nighttime sleepers were based on t-tests, comparisons of academic performance and stress levels between daytime and nighttime sleepers were based on chi-square tests. Weeknight bedtime, weekday rise time, weekend bedtime and weekend rise time are presented as the mean hour: minutes ± SD (hour: minutes); sleep latency is presented as the mean ± standard deviation in minutes and total sleep time is presented as the mean ± SD in hours.

returning from university). In addition to weeknight bedtimes, daytime sleepers significantly differed from nighttime sleepers in all sleep habits except for sleep latency. Day sleepers had more hours of sleep compared with night sleepers (5.8 versus 5.7 hours) (*p*=0.031). Additionally, daytime sleepers slept approximately one hour later than nighttime sleepers during the weekends (03:36 versus 02:30), and they awoke one hour and 20 minutes later than night sleepers (11:05 and 12:21; *p*=0.042 and 0.006). The associations between demographic and lifestyle factors and sleep patterns were non-significant, except for hypnotic medication use. Specifically, 18% of the students who used hypnotic medication fell into the category of "daytime sleepers",

while only 7% of the students who did not use hypnotic medication fell into this category (*p*=0.017).

Prevalence of disturbed sleep, EDS, and insomnia symptoms, and their association with stress, academic performance, and other factors. **Table 4** shows the prevalence of disturbed sleep, EDS, and insomnia symptoms. Approximately 30% of the students reported that they viewed their sleep quality to be fairly poor or very poor during the previous month. Excessive daytime sleepiness was reported by approximately 40% of the students. In terms of insomnia symptoms, approximately one-third of the students reported not being able to fall asleep within 30 minutes of going to bed at least 3 times per week during the previous month. Moreover, most students (84%) reported insufficient sleep (sleeping less than 8 hours each night).

Table 5 presents factors that showed significant associations with poor sleep quality, EDS, and insomnia symptoms. Average or high stress levels were significantly associated with poor sleep quality, EDS, and frequent nighttime awakenings. Compared with students with low stress levels, students with average levels had approximately 10 and high stress levels approximately 24 times greater odds of reporting poor sleep quality. The odds of having excessive daytime sleepiness were also 3 times greater in students who had average and high stress levels, compared with those with low levels. Poorer academic performance and higher stress levels were also associated with significantly higher odds of reporting insomnia symptoms.

Table 4 - Prevalence of disturbed sleep, excessive daytime sleepiness (EDS), and insomnia symptoms among medical students. (n=305)

Sleep-related outcome	n	%
Sleep quality		
Normal	214	(70)
Poor	91	(30)
EDS		
Normal	187	(61)
Excessive daytime sleepiness	118	(39)
Insomnia		
Inability to sleep within 30 minutes	81	(27)
Nighttime awakening	47	(15)
Insufficient sleep	256	(84)

Poor sleep quality was defined as fairly poor or very poor self-reported sleep quality, EDS was defined as an ESS score >10 and insomnia symptoms were defined as the inability to sleep within 30 minutes (3 or more times/week) or frequent awakenings at night (3 or more times/week).

Table 5 - Odd ratios and standard errors (SE) of variables with significant associations to poor sleep quality, excessive daytime sleepiness (EDS), and insomnia symptoms. (n=305)

Sleep-related outcome	Significant predictors	Odds ratio	SE	*P*-value
Poor sleep quality	Low stress level	Ref	---	---
	Average stress level	9.6	10.2	0.033
	High stress level	24.0	24.6	0.002
	Hypnotic medication use	2.7	1.2	0.029
EDS	Low stress level	Ref	---	---
	Average stress level	3.1	1.5	0.021
	High stress level	3.1	1.4	0.011
	Napping	1.6	0.3	0.029
Inability to sleep within 30 minutes	Lower academic performance	1.6	0.3	0.026
Nighttime awakening	Low stress level	Ref	---	---
	Average stress level	2.9	1.2	0.011
	High stress level	3.3	1.2	0.001
	Lower academic performance	1.5	0.3	0.041

Poor sleep quality was defined as fairly poor or very poor self-reported sleep quality. Excessive daytime sleepiness was defined as an Epworth sleepiness scale score >10 and insomnia symptoms were defined as the inability to sleep within 30 minutes (3 or more times/week) or frequent awakenings at night (3 or more times/week). Logistic regression (backwards elimination technique) results are presented as odds ratios and SE.

Discussion. The current study revealed poor sleep-wake habits among medical students. On average, the students went to bed at a late hour (01:53) and did not obtain sufficient hours of sleep, as the average hours slept each night were 5.8 hours. A delay in weekend bedtime and weekend rise time was also found. Moreover, a predominant daytime sleeping schedule, in which students remained awake all night and slept during the day after returning from university, was reported by 8% of the students. Complaints of poor sleep quality (sleep disturbance) were reported by 30% of students, and approximately 40% had excessive daytime sleepiness. Insomnia symptoms were also prevalent among the students. Our findings also showed that high stress levels were significantly associated with poor sleep quality, EDS, and frequent nighttime awakenings. Additionally, poorer academic performance was associated with a higher frequency of insomnia symptoms, namely, not being able to sleep within 30 minutes of going to bed and frequent nighttime awakenings.

In terms of associations between stress, academic performance, and sleep-wake patterns, our results revealed that students across all academic performance levels and all stress levels showed similar patterns of total hours of sleep, sleep latency, weeknight bedtime, weekend bedtime, and weekend rise time. Similar to the current findings, a study from Malaysia[21] on Biomedical college students did not find a significant correlation between total hours of sleep (≤6 hours or >6 hours) and cumulative GPA (excellent or below excellent). However, other studies that investigated total hours of sleep as a predictor of GPA found that among the variables examined, hours slept was the single most significant predictor of GPA.[22]

The only sleep-wake pattern outcome that was significantly associated with academic performance in the current study was weekday rise time. As grades deteriorated, rise times became more delayed. On average, students with excellent grades awoke at 06:36, those with very good grades awoke at 07:14, and students with poor grades (good or below) awoke at 07:32. Interestingly, a study[23] that evaluated the effects of health-related factors on the academic achievement of first year college students found that lower GPAs were associated with later rise times. Of all of the variables examined, sleep, and particularly rise times, accounted for the largest percentage of variance in academic achievement.[23] The examined variables included exercise, eating habits, mood states, perceived stress, time management, social support, spiritual or religious habits, working hours during the week, age, and gender.

Despite the absence of a significant difference between students in their weekday sleep time and weekend sleep and wake up time based on academic performance and stress, we can observe from our findings that all students seem to acquire insufficient sleep during weekdays (5.8 hours), and have rebound sleep, commonly known as making up for sleep debt, during the weekend. Although our data limits us from examining TST, sleep onset, and other parameters during the weekend, we can see that the average wake up time during weekends is delayed by over 4 hours (from 07:08-11:14). These findings are similar to those observed in other student populations.[24] Factors such as early class start times may play a major role in short sleep durations during weekdays and a resulting need to make up for sleep debt in the weekend. Lima et al[24] have demonstrated that medical students who start classes late are more likely to acquire longer hours of sleep during the week, compared with students who start class early.[24] These findings are not unique to college students and are similarly present among adolescents in high school.[25]

The current study findings reflect that stress may not influence the timing of sleep, or amount of sleep that students acquire during the week or the weekends. Rather, it may influence their sleep quality and their levels of daytime sleepiness. A significant association between higher levels of stress and sleep disturbance in college students has been shown in previous studies.[26,27] Additionally, some studies have supported the theory that stress is a mediating factor in the relationships between wellbeing habits and sleep quality in college students. For example, a study[28] of 166 college students found that perceived stress was a significant mediator in the relationship between greater mindfulness and improved sleep quality. A large study[29] of 1125 college students from the United States found that tension and stress accounted for one-quarter (24%) of the variance in sleep disturbance as measured by PSQI. Higher levels of daytime sleepiness were also associated with higher levels of stress in a study[16] of high school students.

In the current study, students with poorer academic performance more frequently reported symptoms of insomnia defined as an inability to fall asleep within 30 minutes, and frequent nighttime awakenings. As grades decreased from excellent to very good, and then to good or below, students had a 60% increase in the odds of reporting an inability to fall asleep within 30 minutes of going to bed and reporting frequent night time awakenings. These findings are not consistent with a recent large study[30] that assessed the prevalence and correlates of insomnia in college students. In this study,

Taylor et al[30] found no significant association between chronic insomnia and academic performance. However, similar to the current study, they observed a significant association between stress and insomnia.

An interesting sleep behavior phenomenon that is found in this study is the predominant daytime sleep pattern that is found among 8% of students. This group of students is found to sleep on average at 13:05 in the afternoon each day, and to wake up at approximately 18:40 in the evening, compared with nighttime sleepers who sleep on average at 00:51 and wake up at 07:11 during weekdays. Gaining better insight into such sleep behavior mandates trying to address possible reasons for such delayed sleep times, or what has been labelled before as a 'reversed sleep schedule' reflecting a reverse from the average sleep-wake times in the general population.[16] The age-specific circadian rhythm properties of this age group may have a large impact on such sleep patterns. In general, adolescents and young adults seem to have the most delay in their circadian rhythm compared with other age groups,[31] reaching the most extreme 'lateness' of their circadian-induced sleep time at around the age of 20.[31] It is suggested that endocrine factors underlie such changes in the circadian rhythm clock.[31] In addition to this physiological delay, delayed sleep phase disorder (DSPD), which is a circadian rhythm abnormality (present among 0.2% and 10% of individuals most commonly among young adults), may explain such a delayed pattern in sleep.[32] The DSPD is defined as a more than 2-hour delay in the major sleep period in respect to socially acceptable times. Our findings show that daytime sleepers have an average bedtime at 03:36 during the weekend. This is over an hour delay from nighttime sleepers' weekend sleep time. Weekend days have also been called 'free days', as students are not committed to early morning awakening.[31] They may reflect the more natural tendency of individuals' sleep preference. These findings may indicate that daytime sleepers may be a group that suffers from DSPD. However, such a diagnosis can only be determined by obtaining information from a thorough history and sleep diary with actigraphy.[32]

Of even more importance is trying to explain the sleep behavior of this group of students during the week, when they are attending medical school. The average sleep time of daytime sleepers surpasses a 12-hour difference from the average sleep time of nighttime sleepers. Despite possible circadian rhythm and chronotype influences, behavioral, psychological, and cultural influences on sleep behaviors cannot be ruled out.[31] Arguably, psychological (for example, the stress of medical school or the inability to wake up in the early morning if allowing oneself to sleep at such a late hour), or environmental factors (for example, a much quieter household during the night), may be driving these students to choose to stay up all night, perhaps to study, then attend university, and then sleep after returning from university during daytime. The discrepancy between the weekday and weeknight sleep schedule for this group may support such intentional behavioral explanations.[32] It is also intriguing to see that results from the multivariable logistic regression models performed in this study show that daytime sleepers were not at a significantly increased risk (or odds) of reporting insomnia symptoms or daytime sleepiness (only the factors with significant associations to these outcomes are presented in **Table 5**). Patients who suffer from DSPD typically exhibit symptoms of an inability to wake up at desired hours, and excessive daytime sleepiness, particularly in the early morning.[32] It has also been demonstrated that, especially during the early morning hours, these patients tend to have deteriorated work and academic performance.[32] However, our analysis shows that daytime sleepers do not significantly differ from nighttime sleepers in measures of academic performance or stress levels. All of these findings lead us to consider the possibility that, given the high stake present in performing academically well in medical school, this group of students have developed an intentional, behavioral mechanism (daytime sleeping) as an attempt to overcome the typical negative symptoms and performance deterioration seen with DSPD. Such explanations can only be explored and confirmed in future studies dedicated to this group of students. A cultural influence must also be considered as a motivational factor underlying such sleep habits, as previous research has shown that similar sleep behaviors are present among high school students in the same community.[16]

Study limitations. The study utilises a cross-sectional design. Therefore, stress, academic performance, and sleep variables were collected at the same time point and inquired regarding the recent past. This factor limits the ability to draw causal inferences due to the temporality of these relationships cannot be established. Moreover, recall bias may influence the validity of the findings. Longitudinal studies that examine the association between stress, academic performance, and sleep may help distinguish between-subject variation at a given time point and within-subject variation over time. Another limitation of the study is the absence of assessment of the following factors, which may underlie or influence some students' choice to stay up all night and sleep during the day: 1) sleep habits over

a longer period; 2) validated measures of chronotype; 3) living arrangements; 4) other relevant lifestyle and demographic factors. In addition, we recommend that in future studies, researchers collect more detailed information on weekend sleep habits and quality, to be able to compare them with weekday parameters.

Medical students who complain of poor sleep quality, excessive daytime sleepiness, and insomnia symptoms may benefit from educational efforts that highlight a strong association between higher levels of stress, worse academic performance, and these complaints. Students can be counselled and encouraged to adopt habits that can decrease their levels of perceived stress and improve their academic performance as needed. Developing college policies that can promote healthier and more adequate sleep among medical students can have large impacts on their performance and overall wellbeing.[25]

In conclusion, our study findings show that medical students in clinical years go to sleep at late hours and acquire insufficient hours of sleep. In addition, self-reported poor sleep quality, excessive daytime sleepiness, and insomnia symptoms are prevalent. Significant associations were observed between higher levels of stress and poor sleep quality, EDS, and nighttime awakening. Moreover, lower academic performance is associated with insomnia symptoms. The importance of acquiring sufficient and good quality sleep for medical students is reflected in the role they play in patients' wellbeing and outcomes, in addition to their own wellbeing and career success. This warrants giving attention to this important aspect in medical students' life through educational interventions. Moreover, the presence of a pattern of predominant daytime sleeping among some medical students, and the need to disentangle the direction of association between stress, academic performance, and sleep parameters warrants further investigation.

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Statistics

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