The interaction between sleep quality and academic performance

K. Ahrberg a, M. Dresler b, S. Niedermaier b, A. Steiger a, L. Genzel a, b

a Max-Planck-Institute of Psychiatry, Kraepelinstr.2-10, 80804 Munich, Germany
b Dr-von-Haunersches-Kinderhospital of Ludwig-Maximilian-University Munich, Munich, Germany

ARTICLE INFO

Article history:
Received 30 April 2012
Received in revised form 31 September 2012
Accepted 12 September 2012

Keywords:
Sleep quality
University
PSQI
Grades
Education
stress

ABSTRACT

Sleep quality has significant effects on cognitive performance and is influenced by multiple factors such as stress. Contrary to the ideal, medical students and residents suffer from sleep deprivation and stress at times when they should achieve the greatest amount of learning. In order to examine the relationship between sleep quality and academic performance, 144 medical students undertaking the pre-clinical board exam answered a survey regarding their subjective sleep quality (Pittsburgh sleep quality index, PSQI), grades and subjective stress for three different time points: semester, pre- and post-exam. Academic performance correlated with stress and sleep quality pre-exam (r = 0.276, p < 0.001 and r = 0.158, p < 0.03, note that low performance meant low sleep quality and high stress), however not with the stress or sleep quality during the semester and post-exam. 59% of all participants exhibited clinically relevant sleep disturbances (PSQI > 5) during exam preparation compared to 29% during the semester and 8% post-exam. This study shows that in medical students it is not the generally poor sleepers, who perform worse in the medical board exams. Instead students who will perform worse on their exams seem to be more stressed and suffer from poor sleep quality. However, poor sleep quality may negatively impact test performance as well, creating a vicious circle. Furthermore, the rate of sleep disturbances in medical students should be cause for intervention.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Many findings in recent years point toward the importance of sleep for memory consolidation: Sleep seems to stabilize as well as enhance a wide variety of memory contents (Diekelmann and Born, 2010). Not only the consolidation of memories, also the encoding itself is negatively influenced by sleep deprivation (Van Der Werf et al., 2009; Yoo et al., 2007; Van Der Werf et al., 2011). Furthermore, sleep inspires insight into hidden rules and facilitates generalization of knowledge (Ellenbogen et al., 2007; Gómez et al., 2006; Wagner et al., 2004). All these cognitive competences are of great importance during higher education, often considered the most demanding and challenging learning period in many people’s life. Especially medical students are expected to retain a large amount of complex factual knowledge in a comparably short time period.

Many studies strongly suggest that timing of sleep as well as its quality and quantity are linked with students’ learning abilities and academic achievement and that students are often chronically sleep deprived (Curcio et al., 2006; Wolfson and Carskadon, 2003). Studies have indicated that over 60% of college students were poor-quality sleepers, resulting in daytime sleepiness and an increase of physical and psychological health problems (Lund et al., 2010; Sing and Wong, 2010). Another study investigating medical-students could not only show significant sleep disturbances, these problems were also related to depressive symptoms (Eller et al., 2006). Beebe et al. (2010) restricted sleep in a simulated classroom, which led to lower quiz scores, more inattentive behaviors and lower arousal. Due to an impressive workload sleep disturbances seem especially prevalent in medical students and residents (Nojomi et al., 2009), an alarming fact considering the clinical responsibilities of these populations. People working in medical fields also often suffer from large amounts of stress; and stress and sleep have long time been known to co-enact with each other (Friedman et al., 1995; Hall et al., 2000; Kachikis and Breitkopf, 2012; Morin et al., 2003; Van Reeth et al., 2000; Kashani et al., 2011). Acute and chronic stressors have pronounced effects on sleep architecture and circadian rhythms and sleep deprivation is a stressor (Van Reeth et al., 2000). Both sleep and stress are closely linked to the hypothalamo-pituitary-adrenal (HPA) axis, which explains the close interrelationship between these two factors (Steiger, 2003; Van Reeth et al., 2000).
In a recent study (Genzel et al., sub) investigating circadian rhythms and academic performance in a side-analysis we observed a significant correlation between current sleep quality and performance in the pre-clinical board exam in medical school. However, the sleep quality was assessed over one year after the board exams, and a causal relationship could not be determined. We therefore investigated in a new sample the sleep quality and stress levels in students before, during and after exam preparation for the pre-clinical board-exams with the goal to further clarify the relationship between sleep, stress and academic performance.

2. Methods

2.1. Procedures

The pre-clinical board-exam is the first comprehensive examination within medical school in Germany and takes place after four semesters. During the preceding 2 months no classes are scheduled to enable a free learning period. The successful completion of the exams allows medical students to enter clinical training.

For this study, 943 medical students of the University of Munich, who were eligible to take the pre-clinical board-exams, were asked to participate in a web-based survey. Of the 943 students 632 took the actual exams. Students were invited to fill out the survey for three different points of time: during the semester, during the preparation phase for their exam (pre-exam) and 8 weeks after completion of the exam (post-exam). In total, 144 students (95 females, age 19–31 yrs, mean ± SD 22.4 ± 2.48) completed the survey for all three time points. The survey included a 10-point rating stress-scale, questions about the pre-clinical-board-exam-grade, sociodemographic characteristics and the Pittsburgh sleep quality index (PSQI) as a measure of subjective sleep quality (Buysse et al., 1989). The PSQI comprises 10 questions related to sleep habits over a one-month period. It includes subscales assessing sleep latency, sleep duration, sleep disturbances, and daytime-dysfunction. Several psychometric aspects of the PSQI have been investigated and reported, such as internal consistency, reliability and construct validity, and stability over 1 year among a population-based sample (Curcio et al., in press; Backhaus et al., 2002; Buysse et al., 1989; Knutson et al., 2006; Carpenter and Andrykowski, 1998). A global score above 5 has been found to be a reliable and validated indicator for clinically relevant pathological sleep (Backhaus et al., 2002; Curcio et al., in press; Aloba et al., 2007). Academic performance was reported in the German grade system which ranges from 1 to 5 with 1 being the best grade.

For the semester the students filled out the PSQI and stress scale considering the time period from April until July. The pre-exam questionnaires could be filled out for 7 days prior to the exam and the students were asked to consider the previous 4 weeks, while the post-exam questionnaires were sent out 8 weeks after the exam and again the students were asked to consider the previous 4 weeks. Each time the students had a 1 week period to fill out the questionnaires.

The Ethics Committee of the Ludwig-Maximilian-University Faculty of Medicine, Munich/Germany, approved this research project and the study was carried out in accordance with the latest version of the Declaration of Helsinki.

2.2. Statistics

We performed one-tailed spearman correlation analyses between the variables grade, stress and PSQI. Partial correlation with the variables grade and stress/PSQI with PSQI and stress respectively as covariates were additionally calculated. Further, we calculated a MANOVA with within-subject factor time with three levels (semester, pre-exam, post-exam), between-subject factor grades with two levels (≥median, <median) and the dependent variables stress and PSQI. Sleep latency and length was extracted from the PSQI questionnaires and changes across time (semester, pre-exam, post-exam) in sleep latency, sleep length and percentage of students with PSQI > 5 was tested with ANOVAs with repeated measures.

3. Results

The average grade of the 144 students in this study did not significantly differ from the grades achieved by all 632 students taking the exam at the university (mean ± SD 2.57 ± .88 and 2.61 ± .78 respectively, T774 = 0.595, P > 0.5).

Academic performance was associated with the level of stress and sleep quality pre-exam (stress: r = 0.276, P < 0.001; PSQI: r = 0.158; P < 0.03; note that low performance meant low sleep quality (high PSQI) and high stress. PSQI and stress are presented as the mean and SEM of the 144 students for the different possible grades (1–5 in 0.5 steps).
During exam preparation 59% of the students exhibited poor sleep quality (PSQI > 5) with a mean PSQI score of 6.3 ± 2.6, whereas the percentage of poor sleepers was at 29% (mean PSQI score 4.6 ± 2.3) during the semester and dropped to 8% post-exam (mean PSQI score 3.1 ± 1.9; see Fig. 2B). An ANOVA showed a significant effect of time on the percentage of poor sleepers (F2,142 = 71.106, P < 0.001) and the pairwise comparisons showed that each time point significantly differed from each other time point (all P < 0.001). The subscales contributing primarily to these high PSQI-scores were sleep latency (pre-exam, post-exam: F2,142 = 55.580, P < 0.001) on sleep latency. Pairwise comparisons showed that sleep latency at each time point significantly differed from each other time point (pre-exam–semester: T143 = 3.723, P < 0.001; pre-exam–post-exam: T143 = 9.118, P < 0.001; semester–post-exam: T143 = 5.007, P < 0.001).

Mean total sleep time during the three time points “semester”, “pre-exam” and “post-exam” were 7.8 h ± 0.95, 7.3 h ± 0.93 and 8.6 h ± 1.03 respectively. There was a significant effect of time (F2,142 = 68.709, P < 0.001) on sleep length and subsequent T-tests could show that each time point was significantly different than each other time point (pre-exam–semester: T143 = −3.757, P < 0.001; pre-exam–post-exam: T143 = −11.170, P < 0.001; semester–post-exam: T143 = −6.967, P < 0.001).

A MANOVA with within-subject factor time and between-subject factor grade (divided into 2 groups: <median, ≥median) with the repeated measures of stress and PSQI showed a significant time and time x grade effect on the variables (time: F4,139 = 182.97, P < 0.001; time x grade: F4,139 = 2.453, P < 0.05; grade: F4,139 = 2.122, P = 0.124; see Fig. 3). In 2-tailed post-hoc T-test the two groups differed significantly on the values of PSQI and stress pre-exam (PSQI: T142 = 2.258, P = 0.025; stress: T142 = 3.216, P = 0.002), however not during the semester or post-exam (all T142 < 0.5, P > 0.6).

4. Discussion

This study showed that academic performance is linked to sleep quality and stress prior to the exam. Both stress and sleep quality correlated with exam grades, note that low performance meant low sleep quality and high stress; yet, this relationship was not found for the other time points. It seems however that those students who generally sleep poorly do not receive bad grades. Perceived stress has been identified as one major factor contributing to these low scores in sleep quality, resulting in delayed sleep onset, increased day dysfunction due to sleepiness and reduced subjective sleep quality. In all three time points, stress levels correlated with the PSQI-score, supporting previous findings suggesting a close relationship between these two factors (Vandekerckhove and Cluydts, 2010). Most medical students prepare for their exams by practicing old exam questions, so their performance during studying allows a prediction of their exam grades. Possibly, students, who are expecting lower grades, are likely to suffer from higher stress, resulting at the same time in worse sleeping quality. The high stress and low sleep quality in turn could negatively influence exam preparation and performance, which again negatively influences stress and sleep quality. The outcome is a vicious circle requiring intervention. Another explanation could be that students, who are more resistant to stressors and stay more relaxed and less stressed pre-exam, perform on a higher level on the exam. It might be that it is poor sleep quality that actually affects performance mediated by the negative effect of stress on sleep. Alternatively, poor sleep quality might increase stress resulting from sleep deprivation and stress in turn might affect performance. Also, stress and sleep might independently influence academic performance. Many studies have found a close relationship between sleep and stress (Friedman et al., 1995; Hall et al., 2000; Kachikis and Breitkopf, 2012; Morin et al., 2003; Van Reeth et al., 2000; Kashani et al., 2011). Acute and chronic stressors have pronounced effects on sleep architecture and circadian rhythms and sleep deprivation is a stressor (Van Reeth et al., 2000). Acute stress is accompanied by a decrease in slow wave and REM sleep and after recovery a rebound of these stages is seen (Van Reeth et al., 2000). Both sleep and stress are closely linked to the hypothalamo-pituitary-adrenal (HPA) axis, which explains the close interrelationship between these two factors (Steiger; 2003; Van Reeth et al., 2000). Stress-induced elevation of plasma ACTH is associated with an increase in REM sleep and to a lesser extent in SWS sleep (Van Reeth et al., 2000). With sleep deprivation the modulatory effect of sleep—wake transitions on cortisol release are absent resulting in reduced amplitude of the cortisol profile in the
morning and elevated cortisol the following evening (Van Reeth et al., 2000).

The causal relationship between sleep, stress and academic performance remains unknown and cannot be determined by this study. However, the results do further underline the significant interaction between these factors. Perhaps students would benefit from a cognitive-behavioral approach e.g. meditation or progressive muscle relaxation reducing stress and therefore increasing sleep quality. By increasing sleep quality a positive foundation for memory consolidation and exam performance would be created. Of note, the correlation coefficients were below 0.3 in this study which can be considered as small to medium effect size and may not have reached significance with a smaller population. The Spearman correlations were calculated 1-tailed and the correlation between PSQI and grades would only have reached significance 2-tailed with a sample size of more than 240. However, since other factors as intelligence, previous knowledge, study time etc. should have the largest effect on grades, our findings seem comparatively large. The association between stress and exam grade seemed stronger than PSQI and the grade, especially noticeable in the partial correlations correcting for each the other variable (PSQI for stress/stress for PSQI). Only the stress and grade correlation remained significant with the correlation between PSQI and grades achieving marginal significance. However, including PSQI as covariate did decrease the correlation between stress and grades suggesting that the two factors sleep quality and stress may have a co-acting effect on grades.

More than half of the students pre-exam and almost one-third during semester had a pathological PSQI-score above the clinical cut-off. Our results are consistent with recent studies showing sleep disturbances in more than fifty percent in college populations (Lund et al., 2010; Sing and Wong, 2010). Poor sleep quality in medical students has been related to depressive symptoms and in females — symptoms of anxiety (Eller et al., 2006). Sleep disturbances are important symptoms in many psychiatric diseases e.g. mood and anxiety disorders (Steiger, 2007). Since sleep disturbances often preceed other signs of a depressive disorder, some authors hypothesize that these sleep disturbance may actually cause the drop in mood or that hormone changes first cause sleep disturbances and consecutively the change in mood (Steiger, 2007; Manber and Chambers, 2009).

The questionnaires in this study were sent out to 943 students, who were eligible to take the board exams. Of these 632 students actually took the board exams and again of these 144 students filled out all questionnaires of the study. This results in a return rate of 23%. The average grade of our population was 2.57 in comparison to 2.61 of all students, and they did not significantly differ. This would suggest that our sample is a representative of the general population but perhaps they might be part of a specific subgroup (e.g. having sleep problems, being extraordinary conscientious), which led to their participation in this study.

In our previous study (Genzel et al., sub) we observed a significant correlation between sleep quality during the semester and performance during the pre-clinical board exam in medical school. However, the sleep quality was assessed over one year after the board exams and a causal relationship could not be determined, which led to the current study. In the current study we did not find any relationship between general sleep quality during the semester and the academic performance in the board exam. This difference is surprising, especially since the PSQI during the semester and the grades of both study populations were very similar (PSQI: 4.28 and 4.6, grade: 2.73 and 2.57). We cannot explain this discrepancy; however, we do believe the current results to be more accurate since it was the main focus of the study and not a side-finding as in the previous study and the number of participants is higher (144 vs. 31 students).

To summarize, this study investigated the interrelationship of exam performance, sleep quality and stress. We could show that sleep quality and stress directly prior to the exam but not during the semester or post-exam, *P < 0.05, **P < 0.01.

Author disclosure

All authors report no conflict of interest.
Contributors

K.A. and L.G. designed, performed and analyzed the study. K.A. wrote the first draft of the article. S.N., A.S and M.D. helped design and analyze the study. All authors contributed to writing and discussing the article.

Role of the funding source

The study was funded by the Max Planck Institute of Psychiatry.

Acknowledgments

We would like to thank Karin Samson for the help recruiting the subjects. Further we would like to thank the participants for answering the questionnaire.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jpsychires.2012.09.008.

References

Aloba OO, Adewuya AO, Ola BA, Mapayi BM. Validity of the pittsburgh sleep quality index (PSQI) among Nigerian university students. Sleep Medicine 2007;8:266–70.


