

Association of Sleep Quality with Anxiety and Depression Symptoms among Computer Science Students

Lígia Maria Soares Passos
ligiamaria.soarespassos@gmail.com
Univ. Federal Rural do Rio de Janeiro
Nova Iguaçu, Rio de Janeiro, Brazil

Christian Murphy
cmurphy1@brynmawr.edu
Bryn Mawr College
Bryn Mawr, Pennsylvania, USA

Rita Zhen Chen
ritazhen2@gmail.com
Univ. Federal Rural do Rio de Janeiro
Nova Iguaçu, Rio de Janeiro, Brazil

Marcos Gonçalves Santana
santanamg@gmail.com
Universidade Federal de Jataí
Jataí, Goiás, Brazil

Giselle Soares Passos
passos.gs@gmail.com
Universidade Federal de Jataí
Jataí, Goiás, Brazil

ABSTRACT

The mental health of undergraduate students has become a growing concern, with recent studies showing that students in STEM fields such as Computer Science (CS) are most at risk of exhibiting symptoms of anxiety and depression. However, to date there has been little work in understanding the causes of these symptoms.

This paper presents the results of a study of 146 undergraduate CS students at a public university in Brazil, in which students' sleep characteristics and symptoms of depression and anxiety were assessed using validated questionnaires.

The results demonstrate that 61.0% of CS students reported poor sleep quality, and that 21.9% and 33.6% of CS students were in the clinical anxiety and clinical depression groups, respectively. These results are not unrelated: CS students with poor sleep quality were 6.08 times more likely to be in the clinical anxiety group and were 4.35 times more likely to be in the clinical depression group than CS students with good sleep quality.

CCS CONCEPTS

• **Social and professional topics** → **Computing education.**

KEYWORDS

mental health, sleep quality, students, Computer Science

1 INTRODUCTION

Neurobiological processes associated with sleep are necessary in all species for maintenance of physical and cognitive health, and sleep disorders may cause impairment in school performance, work, family and social relationships [9].

According to [14], several studies have highlighted the relationship between sleep, learning and memory processes. The findings strongly suggest that sleep quality and quantity are closely related to student learning capacity and academic performance, and that

sleep loss is frequently associated with poor declarative and procedural learning in students [14]. In this context, several studies have already investigated the interaction between sleep quality and academic performance [1, 14, 31]. According to [1], sleep quality has significant effect on cognitive performance, and students who perform worse on their exams seem to be more stressed and suffer from poor sleep quality. According to [31], better quality, longer duration, and greater consistency of sleep are strongly associated with better academic performance in college students.

Many prior studies have considered sleep quality among undergraduate students. A meta-analysis considering 57 observational studies on sleep quality among medical students is presented in [34]; the sleep quality and anxiety among dental students is investigated in [27]; in [33], sleep quality and wellness in nursing students is studied, for example.

Discussions about the mental health, which includes questions about sleep quality, of Computer Science (CS) students in particular is incipient, although they have become increasingly important.

Even prior to the COVID-19 pandemic and the ensuing effects of prolonged periods of social isolation and uncertainty, the mental health of undergraduate students was becoming a growing concern [2], with evidence mounting that students in STEM fields including Computer Science (CS) were particularly at risk [15, 32].

The association of positive and negative feelings with anxiety and depression symptoms among CS students during the COVID-19 pandemic was investigated in [39], and the study showed that negative feelings correlated with a higher prevalence of anxiety and depression symptoms, and that the impact was more pronounced in female students than in male students. The sources of CS students' stress and distress are only beginning to be explored [28] and certainly may be wide-ranging, including academic and social pressures, lacking a sense of inclusion and belonging, and aspects inherent to CS as a rigorous field of study.

Previous work has shown that CS students are particularly vulnerable to mental health disorders and have a high prevalence of anxiety and depression symptoms [38]. The authors also reported an observed relationship between anxiety, depression and sleep quality, although sleep quality has been only superficially evaluated on a one-dimensional Likert scale.

According to [9], assessing sleep quality is a complex task, involving quantitative parameters, such as sleep duration and sleep

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latency, in addition to qualitative parameters, which are purely subjective. The Pittsburgh Sleep Quality Index [11] is a standardized self-rated questionnaire, which can be easily understood and answered, that evaluates sleep quality differentiating between “good sleepers” and “poor sleepers” [9]. Since its development, the Pittsburgh Sleep Quality Index has been widely used to measure sleep quality in different groups of people, including college students [17], due to its combination of quantitative and qualitative information on sleep quality, an important feature of this questionnaire [9].

Therefore, in order to demonstrate the pervasiveness of these mental health issues among CS students, particularly the association of sleep quality and anxiety/depression symptoms, this paper presents a study that investigates the following questions:

- (1) What is the prevalence of poor sleep quality among CS students?
- (2) How does sleep quality associate with anxiety and depression symptoms among CS students?

To answer these questions, we conducted a cross-sectional study considering CS students at a public university in Brazil. In this study, only well established psychometric instruments – the Beck Anxiety Inventory [6], the Beck Depression Inventory [8] and the Pittsburgh Sleep Quality Index [11] – were used to measure the levels of anxiety symptoms, depression symptoms, and the sleep quality among these students, respectively.

This paper is organized as follows. In section 2, the methods used in this study are presented. The results are shown in section 3. A discussion is presented in section 4. Finally, the last section concludes this work with a short summary, an assessment of the presented study and an outlook on possible future studies.

2 METHODS

This study was approved by the Ethics Committee on Human Research at the lead author’s institution under protocol number 1270/18, amendment number 6/2020, and conformed to the principles outlined in the Declaration of Helsinki. Only the CS students who signed the consent form participated in these studies, and data were collected online and anonymously via Google Forms.

The present study considers only the regular students in the undergraduate CS program at a Brazilian public university. This population size was 296 students. All the students were invited to participate by a call for participation sent by email and published on social media. We adopted a confidence level of 95% and a margin of error of 6%. Only students over 18 years old were included in the present study.

The data were anonymously collected online, via Google Forms, from November 9 to November 24, 2020. During the data collection, the CS students were attending only remote classes, due to the COVID-19 pandemic.

The CS students participated in this study answering a sociodemographic questionnaire as well as the Beck Anxiety Inventory [6], the Beck Depression Inventory [8], and the Pittsburgh Sleep Quality Index [11], which are described below.

The sociodemographic questionnaire presented the questions *age* and *sex*.

The Beck Anxiety Inventory (BAI) [6] is a 21-question multiple-choice self-report inventory used for measuring the severity of

anxiety symptoms that the subject has had during the past week. The following items are rated: numbness or tingling, feeling hot, wobbliness in legs, unable to relax, fear of the worst happening, feeling dizzy or lightheaded, heart pounding or racing, unsteady, terrified, nervous, feelings of choking, hands trembling, shaky, fear of losing control, difficulty breathing, fear of dying, scared, indigestion or discomfort in abdomen, faint, face flushed and sweating (not due to heat). The possible answers for each item are: absent: not at all; mild: it did not bother me much; moderate: it was very unpleasant, but I could stand it; severe: I could barely stand it. The scale ranges from 0 to 3 (absent, mild, moderate and severe). The total score is given by the sum of each individual item and ranges from 0 to 63. The Brazilian Portuguese version of the BAI was validated for Brazilian university students by [16]. The BAI-16 cut-off presented in [5] – ≤ 16 *non-clinically significant anxiety*; > 16 *clinically significant anxiety* – was adopted for comparisons of BAI with sleep quality, due to its clinical classification.

The Beck Depression Inventory (BDI) [8] is a 21-question multiple-choice self-report inventory used for measuring the severity of depression symptoms that the subject has had during the past week. The answers for each question comprise scores ranging from 0 to 3 (absent, mildly, moderately and severely). The minimum score is 0 and the maximum score is 63. It is a psychometric test that discriminates sub-types of depression and differentiates depression from anxiety [7]. The symptom-attitude categories are as follows: mood, pessimism, sense of failure, lack of satisfaction, guilty feeling, sense of punishment, self-hate, self accusations, self punitive wishes, crying spells, irritability, social withdrawal, indecisiveness, body image, work inhibition, sleep disturbance, fatigability, loss of appetite, weight loss, somatic preoccupation and, finally, loss of libido. The BDI was translated into Brazilian Portuguese and was validated for Brazilian university students by [21, 22]. Many BDI cut-offs are proposed in the literature. For comparisons of BDI with sleep quality, we adopted the BDI-16 cut-off recently suggested in [13], with the following classification: ≤ 16 *non-clinically significant depression*; > 16 *clinically significant depression*.

The Pittsburgh Sleep Quality Index (PSQI) [11] assesses sleep quality over a one-month time interval and provides quantitative and qualitative information on sleep. The Brazilian Portuguese version of the PSQI was validated by [9]. The questionnaire consists of 19 self-reported items and other questions. The nineteen individual items generate seven “component” scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction [11]. The sum of scores for these seven components yields one global score that ranges from 0 to 21, and scores > 5 (PSQI >5) indicate poor sleep quality [9, 11]. The sleep variables analyzed were: self-reported sleep duration, sleep efficiency (SE; ratio between sleep duration and total time in bed multiplied by 100), and sleep onset latency (SOL; the length of time that it takes to accomplish the transition from full wakefulness to sleep). According to [30], a sleep latency > 60 (SOL >60) minutes indicates poor sleep quality, for all age groups.

2.1 Data Analysis

The data were analyzed using the TIBCO Statistica™ software (version 13.5). The quantitative variables were compared between groups using a Mann-Whitney U test by groups (2 groups). Chi-Square tests (for *k* samples) were used to verify associations between nominal or categorical variables when the expected cell sizes were ≥ 5. Odds Ratio (OR), with a 95% Confidence Interval (CI), was calculated by binary logistic regression analysis. Spearman's Rank correlation tests were used to summarize the strength and direction (negative or positive) of a relationship between two quantitative variables. The level of significance adopted was *p* < 0.05.

3 RESULTS

In total, 146 CS students participated in the present study, answering the sociodemographic questionnaire, the BAI and BDI inventories, and the PSQI questionnaire.

The mean and standard deviation (SD) for the variables *age*, *BAI*, *BDI*, and *PSQI* scores, *sleep onset latency*, *self-reported sleep duration* and *sleep efficiency* are shown in Table 1. The count and frequencies for variable *sex*, and the cut-offs *PSQI>5*, *BAI-16* and *BDI-16* are also shown in Table 1.

Table 1: CS Students' Basic Statistics.

Variable	<i>n</i> (%)	Mean ± SD
<i>Age (years)</i>		21.88 ± 2.90
<i>BAI (score)</i>		10.61 ± 8.61
<i>BDI (score)</i>		13.40 ± 9.19
<i>PSQI (score)</i>		6.99 ± 3.23
<i>Sleep Onset Latency (minutes)</i>		37.44 ± 36.0
<i>Self-reported Sleep Duration (hours)</i>		7.05 ± 1.39
<i>Sleep Efficiency (%)</i>		88.86 ± 13.72
Sex		
<i>Female</i>	41 (28.1%)	
<i>Male</i>	105 (71.9%)	
PSQI>5		
<i>No/ Good Sleep Quality</i>	57 (39.0%)	
<i>Yes/ Poor Sleep Quality</i>	89 (61.0%)	
BAI-16		
<i>Non-clinical Anxiety</i>	114 (78.1%)	
<i>Clinical Anxiety</i>	32 (21.9%)	
BDI-16		
<i>Non-clinical Depression</i>	97 (66.4%)	
<i>Clinical Depression</i>	49 (33.6%)	

BAI: Beck Anxiety Inventory

BDI: Beck Depression Inventory

PSQI: Pittsburgh Sleep Quality Index

The mean BAI and BDI scores were compared considering the *PSQI>5* cut-off. The results are shown in Table 2.

The mean *sleep onset latency*, *self-reported sleep duration* and *sleep efficiency* evaluated by *PSQI* were compared considering the *BAI-16* and *BDI-16* cut-offs. Table 3 shows the results.

The *SOL>60* cut-off was associated with *BAI-16* and *BDI-16* cut-offs. We found the following statistically significant differences:

Table 2: Comparison of BAI and BDI Scores considering PSQI>5 cut-off.

PSQI	Mean	SD	p-value
	BAI Score		< 0.0000
<i>Good Sleep Quality (≤ 5)</i>	6.58	5.25	
<i>Poor Sleep Quality (> 5)</i>	13.19	9.34	
	BDI Score		< 0.0000
<i>Good Sleep Quality (≤ 5)</i>	8.81	6.55	
<i>Poor Sleep Quality (> 5)</i>	16.34	9.46	

Mann-Whitney U Test (w/ continuity correction).

BAI: Beck Anxiety Inventory

BDI: Beck Depression Inventory

PSQI: Pittsburgh Sleep Quality Index

Table 3: Comparison of Sleep Onset Latency, Sleep Duration and Sleep Efficiency evaluated by PSQI considering BAI-16 and BDI-16 cut-offs.

Cut-offs	Mean	SD	p-value
Sleep Onset Latency (minutes)			
BAI-16			0.04
<i>Non-clinical Anxiety</i>	33.77	32.46	
<i>Clinical Anxiety</i>	50.50	44.57	
BDI-16			0.0006
<i>Non-clinical Depression</i>	28.97	26.05	
<i>Clinical Depression</i>	54.20	46.04	
Self-reported Sleep Duration (hours)			
BAI-16			0.68
<i>Non-clinical Anxiety</i>	7.09	1.36	
<i>Clinical Anxiety</i>	6.94	1.50	
BDI-16			0.90
<i>Non-clinical Depression</i>	7.04	1.33	
<i>Clinical Depression</i>	7.08	1.51	
Sleep Efficiency (%)			
BAI-16			0.23
<i>Non-clinical Anxiety</i>	89.81	13.23	
<i>Clinical Anxiety</i>	85.49	15.07	
BDI-16			0.15
<i>Non-clinical Depression</i>	89.89	12.90	
<i>Clinical Depression</i>	86.82	15.14	

Mann-Whitney U Test (w/ continuity correction).

BAI: Beck Anxiety Inventory

BDI: Beck Depression Inventory

PSQI: Pittsburgh Sleep Quality Index

BAI-16 (*p* = 0.0113; OR=3.89 (95% CI[1.36, 11.12])) and *BDI-16* (*p* = 0.0004; OR=8.40 (95% CI[2.57, 27.46])).

The *PSQI>5* cut-off was associated with the *BAI-16* and *BDI-16* cut-offs. Table 4 shows the results for the Pearson Chi-square tests and the calculated odds ratios.

Table 4: Association of PSQI>5 Cut-off with the BAI-16 and BDI-16 Cut-offs.

	PSQI>5			
	Yes		No	
	(n)	(%)	(n)	(%)
BAI-16 ($p = 0.0005$; OR=6.08 (95% CI[2.00, 18.46]))				
Non-clinical Anxiety	61	68.5	53	93.0
Clinical Anxiety	28	31.5	4	7.0
BDI-16 ($p = 0.0002$; OR=4.35 (95% CI[1.90, 9.93]))				
Non-clinical Depression	49	55.1	48	84.2
Clinical Depression	40	44.9	9	15.8

Pearson Chi-square test.
BAI: Beck Anxiety Inventory
BDI: Beck Depression Inventory
PSQI: Pittsburgh Sleep Quality Index

We also found the following statistically significant correlations: higher PSQI score with higher BAI ($r_s = 0.53$) and BDI ($r_s = 0.51$) scores.

4 DISCUSSION

The aim of this study is to determine the prevalence of poor sleep quality and to verify the association of sleep quality with anxiety and depression symptoms among CS students.

4.1 Findings

The prevalence of poor sleep quality among CS students was 61.0%, and the mean total PSQI score was 6.99. A meta-analysis considering 57 observational studies on sleep quality among medical students is presented in [34]. The pooled prevalence of poor sleep quality was 52.7% (95% CI: 45.3% to 60.1%) considering the PSQI questionnaire; and the pooled mean total PSQI score across 41 studies was 6.1 (95% CI: 5.6 to 6.5) [34].

A previous study has already shown a high prevalence of anxiety and depression symptoms among CS students [38]. In the present study, 21.9% and 33.6% of CS students were in the *Clinical Anxiety* and *Clinical Depression* groups, respectively.

The subjective sleep quality, measured by PSQI score, was moderately positively correlated with anxiety (Spearman's $r_s = 0.53$) and depression (Spearman's $r_s = 0.51$) scores, measured by BAI and BDI inventories, respectively. The study presented in [4] corroborates these findings, indicating that subjective sleep quality was correlated with anxiety and depression in students.

According to [29], poorer global sleep quality is widely associated with clinically-relevant symptoms of psychological distress, including increased antisocial personality problems, attention deficit/hyperactivity problems, anxiety and depressive problems. As such, the present study shows that those CS students who had *Poor Sleep Quality* had higher BAI and BDI scores than those who had *Good Sleep Quality* (Table 2). Furthermore, the CS students with *Poor Sleep Quality* were 6.08 times more likely to be in the *Clinical Anxiety* group and were 4.35 times more likely to be in the *Clinical Depression* group than the CS students with *Good Sleep Quality* (Table 4). Poor sleep quality was also significantly positively associated with

anxiety (OR=1.38) and depression (OR=1.58) among general college students [20].

A comparison of *sleep onset latency*, *self-reported sleep duration* and *sleep efficiency* considering the BAI-16 and BDI-16 cut-offs (Table 3) has shown that those students in the *Clinical Anxiety* group have higher mean *sleep onset latency* than those in the *Non-clinical Anxiety* group. Additionally, CS students in the *Clinical Depression* group have higher mean *sleep onset latency* than those in the *Non-clinical Depression* group. No difference was found for *self-reported sleep duration* or *sleep efficiency*. Furthermore, the CS students with sleep onset latency > 60 minutes were 3.89 times more likely to be in the *Clinical Anxiety* group and 8.40 times more likely to be in the *Clinical Depression* group than the CS students with sleep onset latency ≤ 60 minutes. According to the DSM-5 [3], high sleep onset latency is one of the symptoms of insomnia. According to [10], insomnia is characterized by difficulty initiating or maintaining sleep, accompanied by symptoms such as irritability or fatigue during wakefulness. An exploration of the direction of risk of the association of insomnia with anxiety and depression disorders is investigated in [25]. According to the authors, any prior anxiety disorder was associated with an increased risk of insomnia and prior insomnia was associated with onset of depression.

4.2 Suggestions

The improvement of students' sleep quality should get attention in order to reduce any negative effects on CS students' mental, physical and cognitive health.

According to [19], music intervention can improve sleep quality in adults, and is effective with large overall effects on PSQI score, overall sleep quality, sleep onset latency and sleep efficiency. The authors found that music assisted relaxation and listening to music are the most significant effective intervention arms for sleep onset latency [19]. In [24], participants listened for 45 minutes either to relaxing classical music (Group 1) or an audiobook (Group 2) at bedtime for 3 weeks. The control group (Group 3) received no intervention. Sleep quality was measured using the PSQI before the study and weekly during the intervention. Depressive symptoms were measured using the BDI. The results has shown that listening to relaxing classical music improved sleep quality and decreased depressive symptoms in students aged between 19 and 28 years.

Mindfulness meditation programs have moderate evidence to improve anxiety and depression symptoms [23], and preliminary findings suggest that mindfulness meditation may be effective in treating some aspects of sleep disturbance [35].

The positive effects of exercise on sleep are well established in the literature [12]. In [40], for example, the authors has shown that low-impact daily physical activity, like walking, can positively affect sleep in healthy adults. Averaged across the month, daily active minutes were positively related to sleep quality; on days when participants were more active than average, both men and women reported better sleep quality and duration [40].

According to the systematic review of literature presented in [18], the current literature supports a bidirectional relationship between sleep and depression. Other studies have also investigated the efficacy of numerous positive activities on improving well-being and ameliorating depression symptoms [37]. According to [26], people

can increase their happiness through simple intentional positive activities, such as expressing gratitude or practicing kindness. As proposed in [36] and suggested in [39], to cultivate self strengths, writing a *three good things list* and a making a *gratitude visit* may increase happiness and decrease depressive symptoms.

The ways in which CS students may be able to improve sleep quality, and reduce anxiety/depression symptoms may include, in addition to medical and psychological support, listening to relaxing classical music, mindfulness meditation, physical activity, and simple intentional positive activities as the one described above. All of these practices are safe, simple, self-administered, cost-free and can help CS students improve their sleep quality and well-being. CS educators should encourage their students to engage in these activities.

4.3 Limitations

A potential limitation of this study is the online data collection and the calls for participation sent by email and published on social media, which could affect the opportunity that some students had to participate in the study. However, there was no other way to collect these data during remote classes. Another potential limitation of this study is the data collection during the COVID-19 pandemic, which may have negatively impacted the CS students' sleep quality.

5 CONCLUSION

In this paper, we have presented our results in attempting to understand the association of sleep quality with the prevalence of anxiety and depression symptoms among CS students.

As this work only focuses on a single institution, and data were collected during the COVID-19 pandemic, which may have negatively impacted the CS students' anxiety/depression symptoms as well as their sleep quality, further investigation is required to determine whether these results would be the same at other institutions, for other groups of students, or whether they are unique to CS students.

However, we believe that the suggestions presented here as a way of reducing symptoms of anxiety and depression will be to the benefit of all students.

And considering that studies about CS students' mental health are incipient, we hope that by sharing our experiences, we will motivate others to conduct similar studies considering CS students from other universities, cities, states and countries, to enable a deeper comprehension of CS students' mental health.

REFERENCES

- [1] K. Ahrberg, M. Dresler, S. Niedermaier, A. Steiger, and L. Genzel. 2012. The interaction between sleep quality and academic performance. *Journal of Psychiatric Research* 46, 12, 1618–1622.
- [2] American College Health Association. 2018. *American College Health Association-National College Health Assessment II: Undergraduate Student Executive Summary*. American College Health Association. https://www.acha.org/documents/ncha/NCHA-II_Fall_2018_Undergraduate_Reference_Group_Executive_Summary.pdf.
- [3] American Psychiatric Association. 2013. *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). American Psychiatric Association, Washington, DC.
- [4] Christoph Augner. 2011. Associations of Subjective Sleep Quality with Depression Score, Anxiety, Physical Symptoms and Sleep Onset Latency in Young Students. *Central European Journal of Public Health* 19, 2, 115–117. <https://cejph.szu.cz/artkey/cjp-201102-0010.php>
- [5] Gerta Bardhoshi, Kelly Duncan, and Bradley T. Erford. 2016. Psychometric Meta-Analysis of the English Version of the Beck Anxiety Inventory. *Journal of Counseling & Development* 94, 3, 356–373.
- [6] Aaron Temkin Beck, Norman Epstein, Gary Brown, and Robert A. Steer. 1988. An inventory for measuring clinical anxiety: psychometric properties. *Journal of consulting and clinical psychology* 56, 6, 893–897.
- [7] Aaron T. Beck, Robert A. Steer, and Margery G. Carbin. 1988. Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clinical Psychology Review* 8, 1, 77 – 100. <http://www.sciencedirect.com/science/article/pii/0272735888900505>
- [8] Aaron Temkin Beck, C. H. Ward, M. Mendelson, J. Mock, and J. Erbaugh. 1961. An Inventory for Measuring Depression. *JAMA Psychiatry* 4, 6, 561–571.
- [9] Alessandra Naimaier Bertolazi, Simone Chaves Fagundes, Leonardo Santos Hoff, Eduardo Giacomolli Dartora, Iلسis Cristine da Silva Miozzo, Maria Emilia Ferreira de Barba, and Sérgio Saldanha Menna Barreto. 2011. Validation of the Brazilian Portuguese version of the Pittsburgh Sleep Quality Index. *Sleep Medicine* 12, 1, 70–75.
- [10] Daniel J. Buysse. 2013. Insomnia. *JAMA* 309, 7, 706–716.
- [11] Daniel J. Buysse, Charles F. Reynolds, Timothy H. Monk, Susan R. Berman, and David J. Kupfer. 1989. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research* 28, 2, 193–213.
- [12] Mounir Chennaoui, Pierrick J. Arnal, Fabien Sauvet, and Damien Léger. 2015. Sleep and exercise: A reciprocal issue? *Sleep Medicine Reviews* 20, 59 – 72.
- [13] Bongjae Choi, Geumsook Shim, Bumseok Jeong, and Sungho Jo. 2020. Data-driven analysis using multiple self-report questionnaires to identify college students at high risk of depressive disorder. *Scientific Reports* 10, 7867–.
- [14] Giuseppe Curcio, Michele Ferrara, and Luigi De Gennaro. 2006. Sleep loss, learning capacity and academic performance. *Sleep Medicine Reviews* 10, 5, 323–337.
- [15] Andrew Danowitz and Kacey Beddoes. 2018. Characterizing Mental Health and Wellness in Students Across Engineering Disciplines. *Proc. of the 2018 Collaborative Network for Engineering and Computing Diversity Conference*.
- [16] Flávia de Lima Osório, José Alexandre S. Crippa, and Sonia Regina Loureiro. 2011. Further psychometric study of the Beck Anxiety Inventory including factorial analysis and social anxiety disorder screening. *International Journal of Psychiatry in Clinical Practice* 15, 4, 255–262. <https://doi.org/10.3109/13651501.2011.605955>
- [17] Jessica R. Dietch, Daniel J. Taylor, Kevin Sethi, Kimberly Kelly, Adam D. Bramoweth, and Brandy M. Roane. 2016. Psychometric Evaluation of the PSQI in U.S. College Students. *Journal of Clinical Sleep Medicine* 12, 08, 1121–1129. [arXiv:https://jcs.m.aasm.org/doi/pdf/10.5664/jcs.m.6050](https://arxiv.org/abs/https://jcs.m.aasm.org/doi/pdf/10.5664/jcs.m.6050)
- [18] João Dinis and Miguel Bragança. 2018. Quality of Sleep and Depression in College Students: A Systematic Review. *Sleep Sci.* 11, 4, 290–301. <http://www.sleepscience.org.br/details/528>
- [19] Fan Feng, Yingshi Zhang, Jun Hou, Jiayi Cai, Qiyu Jiang, Xiaojuan Li, Qingchun Zhao, and Bo an Li. 2018. Can music improve sleep quality in adults with primary insomnia? A systematic review and network meta-analysis. *International Journal of Nursing Studies* 77, 189–196.
- [20] Amer K. Ghrouz, Majumi Mohamad Nooh, Md. Dilshad Manzar, David Warren Spence, Ahmed S. BaHammam, and Seithikurippu R. Pandi-Perumal. 2019. Physical activity and sleep quality in relation to mental health among college students. *Sleep and Breathing* 23, 2, 627–634.
- [21] Clarice Gorenstein and Laura Andrade. 1996. Validation of a Portuguese version of the Beck Depression Inventory and the State-Trait Anxiety Inventory in Brazilian subjects. *Brazilian Journal of Medical and Biological Research* 29, 4, 453–457.
- [22] Clarice Gorenstein, Sabine Pompéia, and Laura Andrade. 1995. Scores of Brazilian University Students on the Beck Depression and the State-Trait Anxiety Inventories. *Psychological Reports* 77, 2, 635–641.
- [23] Madhav Goyal, Sonal Singh, Erica M. S. Sibinga, Neda F. Gould, Anastasia Rowland-Seymour, Ritu Sharma, Zackary Berger, Dana Sleicher, David D. Maron, Hasan M. Shihab, Padmini D. Ranasinghe, Shauna Linn, Shonali Saha, Eric B. Bass, and Jennifer A. Haythornthwaite. 2014. Meditation Programs for Psychological Stress and Well-being: A Systematic Review and Meta-analysis. *JAMA Internal Medicine* 174, 3, 357–368. <https://doi.org/10.1001/jamainternmed.2013.13018>
- [24] László Harmat, Johanna Takács, and Róbert Bádizs. 2008. Music improves sleep quality in students. *Journal of Advanced Nursing* 62, 3, 327–335.
- [25] Eric O. Johnson, Thomas Roth, and Naomi Breslau. 2006. The association of insomnia with anxiety disorders and depression: Exploration of the direction of risk. *Journal of Psychiatric Research* 40, 8, 700–708.
- [26] Sonja Lyubomirsky and Kristin Layous. 2013. How Do Simple Positive Activities Increase Well-Being? *Current Directions in Psychological Science* 22, 1, 57–62.
- [27] Amanda V. Machado, Camila O. Castro, Carlos R. Botelho Filho, Carolina D. Bruzamolín, Rafaela Scariot, Eduardo Pizzatto, and Marilisa C. L. Gabardo. 2020. Anxiety and Sleep Quality in Dental Students at a Private Brazilian University. *The Bulletin of Tokyo Dental College* 61, 1, 27–36.
- [28] Kennedy Manley, Laila Arain, and Christian Murphy. 2021. Addressing Sources of Stress and Distress among Undergraduate Computer Science Students. *Proc. of the 17th International Conference on Frontiers in Education: Computer Science and Computer Engineering*.

- [29] Helen M. Milojevich and Angela F. Lukowski. 2016. Sleep and Mental Health in Undergraduate Students with Generally Healthy Sleep Habits. *PLOS ONE* 11, 6, 1–14.
- [30] Maurice Ohayon, Emerson M. Wickwire, Max Hirshkowitz, Steven M. Albert, Alon Avidan, Frank J. Daly, Yves Dauvilliers, Raffaele Ferri, Constance Fung, David Gozal, Nancy Hazen, Andrew Krystal, Kenneth Lichstein, Monica Mallampalli, Giuseppe Plazzi, Robert Rawding, Frank A. Scheer, Virend Somers, and Michael V. Vitiello. 2017. National Sleep Foundation's sleep quality recommendations: first report. *Sleep Health* 3, 1, 6–19.
- [31] Kana Okano, Jakub R. Kaczmarzyk, Neha Dave, John D. E. Gabrieli, and Jeffrey C. Grossman. 2019. Sleep quality, duration, and consistency are associated with better academic performance in college students. *npj Science of Learning* 4, 1, 16.
- [32] Galen Panger, Janell Tryon, and Andrew Smith. 2014. Graduate Student Happiness and Well-Being Report. http://ga.berkeley.edu/wp-content/uploads/2015/04/wellbeingreport_2014.pdf.
- [33] Sunghee Park, Youngjin Lee, Moonsook Yoo, and Sunyoung Jung. 2019. Wellness and sleep quality in Korean nursing students: A cross-sectional study. *Applied Nursing Research* 48, 13–18.
- [34] Wen-Wang Rao, Wen Li, Han Qi, Liu Hong, Chao Chen, Chun-Yang Li, Chee H. Ng, Gabor S. Ungvari, and Yu-Tao Xiang. 2020. Sleep quality in medical students: a comprehensive meta-analysis of observational studies. *Sleep and Breathing* 24, 3, 1151–1165.
- [35] Heather L. Rusch, Michael Rosario, Lisa M. Levison, Anlys Olivera, Whitney S. Livingston, Tianxia Wu, and Jessica M. Gill. 2019. The effect of mindfulness meditation on sleep quality: a systematic review and meta-analysis of randomized controlled trials. *Annals of the New York Academy of Sciences* 1445, 1, 5–16.
- [36] M. E. Seligman, T. A. Steen, N. Park, and C. Peterson. 2005. Positive psychology progress: empirical validation of interventions. *Am Psychol* 60, 5, 410–421.
- [37] Nancy L. Sin and Sonja Lyubomirsky. 2009. Enhancing well-being and alleviating depressive symptoms with positive psychology interventions: a practice-friendly meta-analysis. *Journal of Clinical Psychology* 65, 5, 467–487.
- [38] Lígia Maria Soares Passos, Christian Murphy, Rita Zhen Chen, Marcos Gonçalves de Santana, and Giselle Soares Passos. 2020. The Prevalence of Anxiety and Depression Symptoms among Brazilian Computer Science Students. In *Proceedings of the 51st ACM Technical Symposium on Computer Science Education (Portland, OR, USA) (SIGCSE'20)*. Association for Computing Machinery, New York, NY, USA, 316–322.
- [39] Lígia Maria Soares Passos, Christian Murphy, Rita Zhen Chen, Marcos Gonçalves de Santana, and Giselle Soares Passos. 2022. Association of Positive and Negative Feelings with Anxiety and Depression Symptoms among Computer Science Students during the COVID-19 Pandemic. In *Anais do II Simpósio Brasileiro de Educação em Computação (Online)*. SBC, Porto Alegre, RS, Brasil, 50–56.
- [40] Alycia N. Sullivan Bisson, Stephanie A. Robinson, and Margie E. Lachman. 2019. Walk to a better night of sleep: testing the relationship between physical activity and sleep. *Sleep Health* 5, 5, 487–494.