REVIEW

Sleep Science

Quality of Sleep and Depression in College Students: A Systematic Review

João Dinis[1]
Miguel Bragança[1]

[1] Faculty of Medicine, University of Porto, Department of Clinical Neurosciences and Mental Health - Porto - Porto - Portugal.

ABSTRACT

Background: Nowadays, sleep-related problems are a prevalent occurrence among university students. Poor sleep quality is one of the most studied aspects of sleep complaints, affecting from 10% to 50% of this population. Poor sleep quality consequences are many and have a profound impact in the student's psychobiological health. University students live through a period of psychological challenge and adaptation, since the transition from high school to professional life. Abrupt autonomy challenges students to deal with many choices, from their academic and social life to their intimate habits. Frequently, sleep hygiene is neglected, or they are unable to use proper coping mechanisms, resulting in disturbing consequences that could impact their lives as adults. Research has found a significant association between sleep quality and depression or depressive symptoms, but this relationship is still somewhat difficult to interpret. **Objective:** The objective of this review is to appraise the current knowledge around the relationship of sleep with depression in this group of young adults. Data Source: Articles included in Medline database. **Methods:** After a careful search, the articles selected aimed mainly college students. The studies had sleep quality and depression objectively assessed, focused in the relationship between both, and addressed possible influencing factors. **Results:** The current literature still supports a bidirectional relationship between sleep and depression, however, the importance of sleep quality is becoming a very relevant variable. **Conclusion:** Education and the application of policies regarding sleep hygiene may prevent, in some cases, the development of depression and improve the quality of sleep in other cases. Future research should clarify the relationship between sleep problems and depression in a way they could be prevented or, at least, minimalized with effective and achievable interventions.

Keywords: Sleep Hygiene; Depression; Students; Universities.

Corresponding author: João Dinis.
E-mail: joaodinis@protonmail.com
Received: June 3, 2018; Accepted: September 7, 2018.

DOI: 10.5935/1984-0063.20180045

INTRODUCTION

When young adults go through university, they experience a period of psychological challenge and adaptation, since the transition from high school to professional life. The sudden autonomy challenges students with varying choices, from their academic and social life to their intimate habits. Frequently, some important dimensions of their lives are sacrificed, being sleep hygiene often neglected, and in the presence of frustration or life changes, they are unable to use proper coping mechanisms, resulting in problematic consequences that could impact their lives through academic life and as adults.

The occurrence of poor mental health among university students varies, but nonetheless the rates of depressive symptoms can go as high as 50% in some countries[1]. Along with this situation, the deterioration of good sleep habits may be contributing to the poor mental health seen in this population. Sleep quality, a measurement that is related to sleep hygiene, has been shown to be poor in this population in different countries, affecting in some cases around 50% of the students[1-3]. An accumulation of research shows that the relationship between disturbed sleep and depression is complex and bidirectional. As this relation is better understood, a dedicated intervention both on sleep quality and depression could prevent the emerging problem in the affected student populations, as well as serving as prevention in the post-graduated young adults.

The aim of this systematic review is therefore to appraise the current available literature that specifically probes this relation, focusing mainly which of the variables of depression, depression symptoms or poor sleep quality may contribute more to the problem. Additionally, this review also aims to appreciate some of the factors that can potentially interfere in this relation. Also understand how do sleep quality and depression impact this population, which instruments are being used to address this subject, what is the current situation in the understanding of the relationship of sleep quality and depression, and how this subject has been studied.

MATERIAL AND METHODS

This review methodological approach has been based in PRISMA's guidelines, available at "prisma-statement.org/". Pubmed was queried for all references from 1970 through July 22, 2017 for studies related to depression associated to sleep in college students or young adults. The search terms were the following: ((Sleep[MeSH Terms]) AND depression[MeSH Terms]) AND adults, young[MeSH Terms]), with 318 results; ((Sleep[MeSH Terms]) AND depression[MeSH Terms]) AND students[MeSH Terms] with 40 results; (("sleep"[MeSH Terms]) AND depression[MeSH Terms]) AND students) with 75 results; ((Sleep[Title/Abstract]) AND Depression[Title/Abstract]) AND Students[Title/Abstract]) with 272 results; In a first phase selection, repeated articles were sorted out, and the remaining articles were selected by title, having as inclusion criteria the combination of the terms "sleep", "sleep quality", "depression", "depressive symptoms", "college", "students", "young adults", "university", "population".

In a second phase, the selected articles were individually read and submitted to the following criteria: 1) any type of article, excluding reviews, meta-analyses and editorial notes; 2) population attending college or young adults not attending to college or any specific education institution; 3) clear methodology and generally accepted data collection instruments, related to assess depression, depressive symptoms, sleep and sleep quality, coherent with the intervention; 4) the outcome would be associated with sleep, sleep quality, depression and depressive symptoms; 5) exclusion of any article in which the outcome would relate intentionally to insomnia or other sleep disturbances, other than affecting sleep quality.

The data retrieved from each article included the study type, the country, the population context, the methodology, the reported limitations, the outcomes regarding the instrument used. Also, data was retrieved concerning other factors the authors consider having influence in the main outcomes in each study.

RESULTS

From the initial search, 705 articles were selected. After the first phase selection, 66 were selected, which followed to be selected in the second phase selection, resulting in 32 articles which were included in the review (Figure 1).

From all articles, 13 were from North America (11 – USA; 1 Canada; 1 Mexico), 10 were from Asia (5- Japan; 3 China; 1 Thailand; 1 Nepal), 2 from Oceania (2- Australia), 2 from Europe (1- Austria; 1- Poland), 2 from Middle East (1- Turkey; 1- Lebanon), 2 from Africa (1- Nigeria; 1- Ethiopia) and 1 study regarding various geographic proveniences.

The study types included 22 cross-sectional studies, 7 longitudinal studies, 1 experimental study, 1 pilot study and 1 quasi-experimental study.

Population

A great portion of the studies included a general college student population (26), although some were specific college schools (Medicine - 2; Nursery - 1; Arts - 1) and two studies included both college students and young adults.

Methodology applied

Regarding sleep and sleep quality the most used instrument used was the Pittsburgh Sleep Quality Score (PSQI), as one article used the PSQI associated with actigraphy. Regarding depression or depressive symptoms, the most used instrument was the Center for Epidemiologic Studies Depression Scale (CES-D), 13 articles and the other articles used a variety of other scales. Table 1 summarizes the methodology applied.

DISCUSSION

The results in this systematic review reinforce the notion that there is a strong association between sleep quality, or sleep hygiene, and depression or depressive symptoms (Table 2). The literature is not consensual of the direction of association, and some authors hypothesize there is a bidirectional association between sleep and depression[4-7]. In terms of cross-sectional

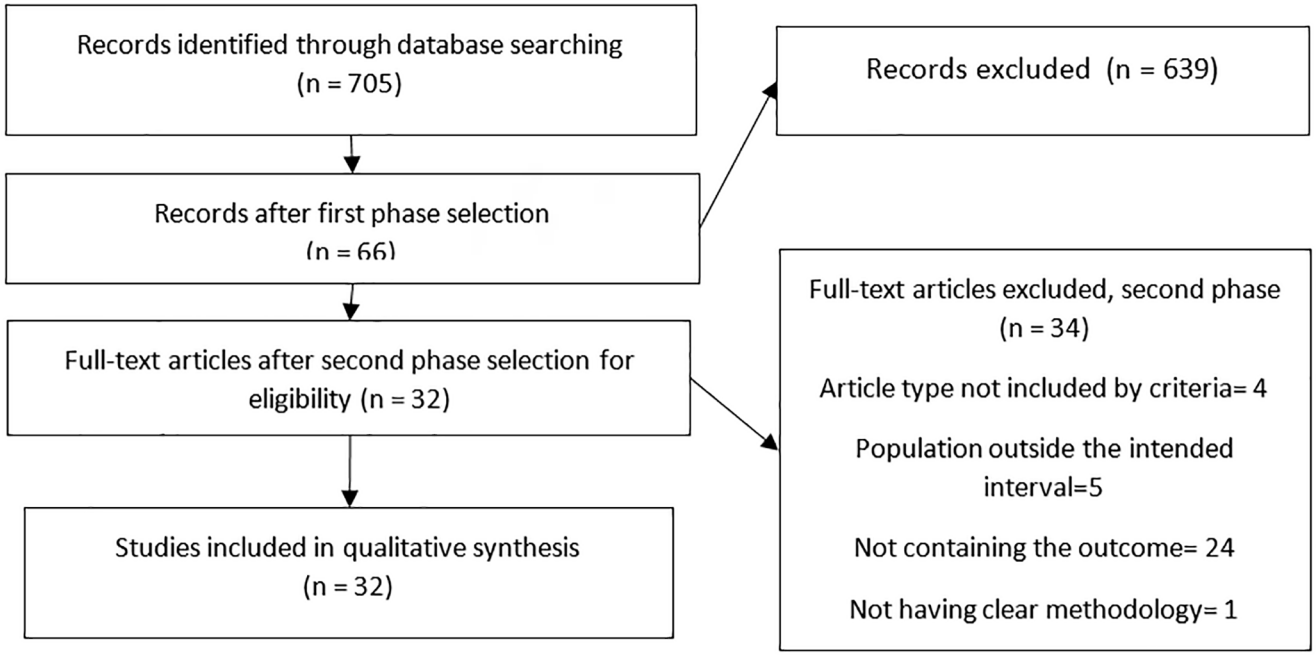

Figure 1. Flowchart of included articles.

Table 1. Methodology Applied in the articles for collection of data regarding sleep, sleep quality, depression and depressive symptoms. Nº. S - Number of studies using the instrument; DS - Depressive symptoms; TMINLHI - Tokyo Metropolitan Institute for Neuroscience Life Habits Inventory; ASQSD - Auckland Sleep Questionnaire and Sleep Diaries; CES-D - Center for Epidemiologic Studies Depression Scale; DASS-21 - Depression, Anxiety and Stress Scale; BDI-II - Beck Depression Inventory; HADS - Hospital Anxiety and Depression Scale; PHQ-9 - Patient Health Questionnaire; MMPI-2 - Minnesota Multiphasic Personality Inventory; SDS - Self-Rating Depression Score; WHO-5 - WHO-Five Well-being Index; * Three articles used a combination of scales, CES-D with DASS 21 or the Hamilton Depression Rating Scale

Sleep/Sleep Quality	Nº. S	Depression/DS	Nº. S
PSQI	22	CES-D	13
Questionnaires from authors	6	DASS 21	6
Sleep Habits Questionnaire	1	BDI-II	5
TMINLHI	1	Combination of scales*	3
ASQSD	1	HADS	1
Sleep Diaries	1	PHQ-9	1
		MMPI-2	1
		SDS	1
		WHO-5	1

studies, there is a greater number of those which support that poor sleep quality predicts depression or depressive symptoms. The other longitudinal studies pointed to a greater risk of depression, or greater presence of depressive symptoms when sleep problems were present[4,5,8-10]. A quasi-experimental study comparing two different types of interventions for improving sleep quality showed reduction in depressive symptoms in both interventions[11]. One experimental study established a model in which poor sleep quality was associated with greater difficulty disengaging attention from negative stimuli, which in turn predicted upsurges in depressive symptoms[12]. There is also evidence that poor sleep quality is associated with greater struggle disengaging attention from negative stimuli, which will increase depressive symptoms[12].

In the perspective of depression, students who are depressed are less likely to use adaptive coping strategies, therefore may experience diminished sleep quality or greater sleep start time variability[10,19]. There is also evidence that as depression increases in severity, the odds ratio or risk of poor sleep quality also increase[1,15]. Episodic and chronic depression are both linked to sleep quality. Despite episodic depressive symptoms being significant predictors of sleep complications, chronic depressive symptoms are particularly greater predictors[4]. Interestingly one of the longitudinal studies, which studied the transition from high-school to college, found that pre-transition depressive symptoms were associated with subsequent post-transition subjective and objective sleep problems, but not the reverse. However post-transition depressive symptoms were concurrently associated with greater sleep problems[8]. In an interesting opposite view, in the point of view from optimism, one longitudinal study found that optimism is a predictor of sleep quality[31].

Regarding the studies' overall results, it´s plausible to affirm that in the presence of a bidirectional relationship, self-reported sleep quality is being shown to be more consistent as a predictor of depression or depressive symptoms, despite depression itself also constitutes a predictor of sleep quality.

Factors influencing sleep quality and depression

Sex

Females have been found to have higher risk of poor sleep quality, which may be associated by the gender-based differences in the biology of sleep[26] or contact to socio-economic

Table 2. SHQ Sleeps Habits Questionnaire; BDI-II Beck Depression Inventory; OR Odds Ration; SD Standard Deviation; PSQI Pittsburgh Sleep Quality Score; CES-D Center for Epidemiologic Studies Depression Scale ; HAM-D3 Hamilton Depression Rating Scale; WHO-5 Self-Rating Depression Scale and the WHO-Five Well-being Index; TMIN-LHI Tokyo Metropolitan Institute for Neuroscience life habits inventory; SDS Self-Rating Depression Score; SF-36 Social Functioning 36; MMPI-2 Minnesota Multiphasic Personality Inventory; DASS-21 Depression, Anxiety and Stress Scale (DASS21); PHQ-9 Patient Health Questionnaire; HADS Hospital Anxiety and Depression Scale.

Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Moo-Estrella et al. (2004)[13]	Cross-Sectional	University of Yucatan, Mexico	College Students from various schools N=638, 53% female; Mean age=20.2±2.6	Questionnaires from events occurring the previous week; SHQ and BDI-II	Students with depressive symptoms had more severe sleep alterations than those without symptoms. The proportion of subjects with depressive symptoms and who reported a nonrestorative sleep was five times higher than that of students with depressive symptoms who had good sleep quality (odds ratio=4.9, 2.03±12.13, p<0.0001)	Self-reported questionnaires; Cross-sectional study; selection bias
Carney et al. (2006)[14]	Cross-Sectional	University in United States of America	College Students from various schools N=243, 87% female; Mean age=20.7±2.9	Questionnaires after a 2-week Social Rhythm Metric evaluation. PSQI determined good and poor sleepers; PSQI and BDI-II	Results showed a significant group effect [F(12, 154) -= 2.15, p<0.017]. Follow- up ANOVAs revealed a statistically significant group effect for "Out of bed," "Into bed." An examination of the means revealed good sleepers were less variable than poor sleepers regarding their rise times, and their bed times. After controlling for depression, poor sleepers continued to have greater variability [F(4, 216) = 2.47, p<0.046]; Lower rates of social engagement and regularity of social engagement seen in poor sleepers	Self-reported questionnaires; Cross-sectional study; the sample of participants was composed predominantly by female Caucasian subjects; the study focus only social zeitbergs
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Regestein et al. (2010)[8]	Longitudinal	University in United States of America	Residents of a woman's college N=339/101, 100% female; ages from 18 to 22 years old	A pilot study 6 week before end of the school year and a main study afterwards; CED-D, HAM D3 and a Sleep Quality Score created by the authors including sleep debt, daytime sleepiness, rising time trouble sleeping; uses of alcohol, sedatives, tranquillizers, or anti-depressants	Diminished sleep apparently risked depressive symptoms. Top quartile Depressive Tendency scores. (chi 2 =42.0; p=0.001) associated with many sleep measures, including late bedtimes (OR=6.5; p=0.01;), greater sleep debt (OR=12.6; Wald chi-square=p=0.0004;), greater sleepiness (OR=8.0; p=0.005; effect size=2.6) and more caffeine drinks daily (OR=5.1; p=0.02)	Self-reported sleep habits; the sample of participants was composed only by females
Augner (2011)[15]	Cross-Sectional	Three nurse's schools in Upper Austria and one technical school in Salzburg, Austria	Students from the mentioned colleges N=196, 76.53% female; Mean age=20.05±3.21	Questionnaires from previous events; Self-created sleep quality scale (How often during the past 2 weeks did you feel drowsy or sleepy during the day? - 0 (never) to 4 (very often); WHO-5	Subjective sleep quality is significantly associated with parameters of mental health (Depression score r=-,57; p<0.001); Best predictors for poor subjective sleep quality were high depression score and long sleep onset latency; Results show significant increased risk of poor sleep experience for persons with high depression score (OR=3.90 [1,88-8,06] p<0.001)	Self-reported questionnaires; Cross-sectional study; High female proportion sample
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Matsumoto et al. (2011)[16]	Cross-sectional	Kurume University, Japan	Male students from the university N=90, 100% men; Mean age=19.4±1.8	Questionnaires from previous events; TMIN-LHI, SDS and a adapted version of SF-36	Mental component of instruments subjects, poor sleep group das significantly poorer evaluation than the scores of any other sleep type. SDS scores in this group were >40(p<0,001). as in SF-36 scores (p<001)	Self-reported questionnaires; Cross-sectional study; the sample of participants was small and composed only by males

Continuation Table 2.

Trockel et al. (2011)[11]	Quasi-experimental	Private University in the United States of America	Students in the 2 first year residence halls N=125, 48.8% female; Ages from 18 to 22 years old	8-week cognitive behavioral therapy for insomnia via e-mail delivery; Questionnaires; PSQI and CES-D	Among students with lower PSQI scores at baseline, there were statistically significant differences between the intervention groups. Participation was associated with greater improvements in sleep quality and greater reductions in symptoms of depression among subjects with low sleep quality at baseline for the most successful intervention: PSQI 7.68 to 5.26 = −2.42 points; Cohen's d = 1.33 and; CES-D 19.69 to 13.75 = −5.94 points; Cohen's d = 0.57	Selection bias; Intervention group population had some degree of heterogeneity; Self-reported questionnaires
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Benitez & Gunstad (2012)[17]	Cross-Sectional	Midwestern University in United States of America	Students from the mentioned university N=67, 64.2% female; Mean age=19.68±1.71	Questionnaires from previous events; PSQI and MMPI-2	Multivariate analysis of variance identified a significant difference between poor and good sleepers on the MMPI-2 RC, F(9,57)=2.471, p<.019, partial η 2 =.281. Post-hoc analyses with a Bonferroni correction identified differences on scales that were related to depression and anxiety, including: Demoralization, Low Positive Emotions, Dysfunctional Negative Emotions	Self-reported sleep habits; Cross-sectional study; modest sample size, composed mostly by females
Carskadon et al. (2012)[5]	Longitudinal	Brown University, United States of America	First-year students from the mentioned university N=135, 60% female; mean ages from 18.0 to 18.2 with different standard deviations from each group	Daily questionnaires and self-reported sleep diaries; DNA samples taken for genotyping; Sleep Diaries and CES-D	Total sleep time (F 3,131=125.87, p<0.001) and CES-D (F 3,131=69.48, p<0.001) showed significant group differences driven by the phenotype grouping parameter. A significant representation of the S'S' genotype for the 5-HTTLPR was seen for participants who reported shorter sleep and high CES-D scores relative to other groups (chi-square=15.04; df=6; p=0.02), even after excluding clinically significant CES-D scored participants (chi-square=12.90; df=6; p=0.045)	Small sample size; Self-reported; Unmeasured third variables, including the possibility of population stratification or linkage disequilibrium between measured and causal variants
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Lemma et al. (2012)[1]	Cross-Sectional	Haramaya University and University of Gondar, Ethiopia	Undergraduate students from second year to final year N=2551, 22.8% female; Median age= 21 years old; 88,6% were between 20 and 24 years old	Subjects assessed by Bi-lingual questionnaires; PSQI and DASS 21	The level of perceived depression has shown significantly increasing odds of poor sleep quality across the quartiles as the level of depression increased from mild to extremely severe with the following odds ratio (95% CI) [1.36 (1.06, 1.75)], [1.64 (1.27, 2.11)], [1.64 (1.11, 2.42)], [2.65 (1.56, 4.49)] respectively	Self-reported sleep habits; Cross-sectional study
Adams & Kisler (2013)[18]	Pilot Study	University in the United States of America	Junior and senior college students N=236, 80% female; Mean age=22.2±4.24	Assessed by questionnaires and 7-day self-reported sleep diaries; PSQI and BDI-II	After controlling for age and gender, poor sleep quality significantly predicted depression b=1.389, p<0.001. Poor sleep quality, age, and gender explained 29.7 percent of variance in depression, F(3,225)=31.256, p<0.001.Sleep quality was a mediator of the relation between technology use and depression b=1.526, p<0.001	Self-report bias; Selection bias
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Kenney et al. (2013)[3]	Cross-Sectional	West coast universities in the United States of America	Undergraduate students N=1044, 66.3% female; Mean age=20.13±1.36	Subjects assessed by questionnaires; PSQI and DASS 21	Poor mental health predicted poor sleep quality (Std. Coefficient= 0.41 p<0,001)	Self-reported bias; Cross-sectional study; Depression was integrated in mental health variable

Continuation Table 2.

Wong et al. (2013)[9]	Longitudinal	Universities and colleges from Hong Cong and Macau	Undergraduate students N=930, 66.6% female; Mean age=21.7±2.2	The study was conducted across three consecutive academic semesters; Subjects assessed by questionnaires; PSQI and DASS 21	Feeling of depression was predicted by daytime dysfunction (Standardized Regression Coefficient, β=.121, *p*=.024) even after we controlled for participants' depression at baseline (β=.621, pb.001)	Self-report bias; Selection bias
Tavernier & Willoughby. (2014)[10]	Longitudinal	University in Southern Ontario, Canada	First-year university students from the mentioned university N=780, 72.2% female; Mean age=19±0.90	Two assessment times with questionnaires; Sleep routines questionnaire made by authors and CES-D	In terms of intrapersonal adjustment, subgroups classified by good sleep characteristics reported significantly better intrapersonal adjustment relative to subgroups characterized by poor sleep characteristics, among both morning-types and evening- types. F (4, 775) =3.645, *p*=0.006	Self-report bias; may not be generalizable; no bidirectional association addressed
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Lovell et al. (2014)[19]	Cross-Sectional	University of the Sunshine, Australia	Students in the mentioned university 18-25 years old group: N=439 (59% sample), 80% female;	Subjects assessed by questionnaires; PSQI and DASS 21	Females and Males with depressive symptoms were more likely to have unhealthy sleep hours than were males or females without depressive symptoms; females (OR=1.98, *p*=0.007) males (OR=4.24, *p*=0.014)	Self-reported, Time period bias; Cross-sectional study; The sample included a portion of older adults (10%)
Matsushita et al. (2014)[20]	Cross-Sectional	Preparatory schools for university entrance and 4 Japanese universities	Undergraduate students and "Ronin-sei" - young adults N=1321, 36.8% female; no data about age	*p*	Greater depressive symptoms if daily sleep duration <5 h (OR=2.01, CI=1.11–3.63, p=0.022), 5to<6 h (OR=1.43,CI= 1.05–1.95, *p*=0.024), and 8 h or more (OR=4.79, CI=1.05–21.90, *p*=0.043) vs. 6 to <7 h; Later bedtime was associated with increased depressive symptoms (OR=1.47, 95% CI=1.12–1.95, *p*=0.006)	Self-report bias; Selection bias; No data about age of the participants
Asaoka et al. (2014)[21]	Cross-Sectional	Japan	University Students and graduated full-time workers N=1105, 48.8% female; ages from 19 to 25 years old	Web-based questionnaire survey; PSQI, CES-D and SF-8	New university graduates experienced ~1 h of sleep phase advancement which revealed that the interaction between current bedtime and that at one year before was significant for the scores of CESD [F (1, 113)=5.52, *p*<0.05], MCS [F(1, 113)=10.09, *p*<0.01], and PSQI [F (1, 113)=4.10, *p*<0.05]	Self-report bias; Recall bias; Cross-sectional study; no data about the weekend sleep phase
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Vanderlind et al. (2014)[12]	Experimental	University of Texas, United States of America	Students in the mentioned university N=35, 40% female; Mean age=19.83±1.25	Assessment with questionnaires; PSQI and CES-D; Actigraphy (Ambulatory Monitoring); participants also completed cognitive and affective measures both at baseline and after the 3-week period	One model ([df = 2]=0.95, p=.62; RMSEA=.00, CFI=1.00) reported Greater sleep difficulty and more sleep stability both significantly predicted greater difficulty disengaging attention (i.e., less cognitive control) from negative stimuli. indirect effects among associations in the initial model for which there was a possible intervening (or mediating) variable. For time 2 depressive symptoms, there was a marginally significant indirect effect for self-reported sleep difficulty (*p*=.07) and a significant indirect effect for sleep stability (*p*=.014). Cognitive control over negative stimuli was the intervening variable for these indirect effects	Self-reported bias; Sample size; Selection bias; study used correlational analyses and several of the associations tested in the path model were cross-sectional

Continuation Table 2.

Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Wilson et al. (2014)[6]	Cross-Sectional	Private women's liberal arts college, United States of America	Students in the mentioned college N=277, 100% female; Mean age=21.4±5.0	Subjects assessed by questionnaires via internet survey; Authors created sleep measurement questionnaire and used CES-D and DASS-21	Poor sleep quality was significantly associated with both CES-D and DASS-21 measures of depression after adjusting for confounders. Students who reported poor/extremely poor sleep quality were more likely to also report prevalent CES-D scores ≥16 (AOR 2.8, 95% CI 1.3–5.8). Similarly, the odds of prevalent DASS-21 depression was 2.8 (95% CI 1.4–5.8) times that of students who self-reported sleep to be excellent, good, or okay	Self-reported bias; Cross-sectional study; the sample of participants was composed only by females
Demirci et al. (2015)[22]	Cross-Sectional	Süleyman Demirel University, Turkey	Students in the mentioned university N=319, 63.6% female; Mean age=20.50±2.45	Subjects assessed by questionnaires; PSQI, BDI-II and Smartphone Addiction Scale	Regression analyses indicated that higher levels of smartphone use and poor sleep quality predicted depression (β=0.226, t=4.131, p<0.01; β=0.448, t=8.173, p<0.01; respectively) In addition, depression predicted poor sleep quality. The findings suggest that depression acted as a mediator between smartphone overuse and sleep quality	Self-report bias; Selection bias; small sample size
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Doane et al. (2015)[23]	Longitudinal	High school and a large southwestern university, United States of America	Students in the senior year in high school which then attended the mentioned university T1: N=82, 76% female; Mean age=18.05±0.41 T2: N=76, 76% female T3: N=71, 77% female	At T1, participants completed a packet of self-report questionnaires (PSQI, CES-D and DASS 21) and portable Actigraphy. The same at T2 and T3. The average time between T1 and T2 assessments was 5.2 months (SD = .96), and the average time between T2 and T3 was 4.1 months	The direct paths examining depressive symptoms and sleep latency were significant across time. There was only one significant prospective effect, with depressive symptoms at T1 predicting increased sleep latency at T2 (β=.24, p<.05). The concurrent, and positive, association between depressive symptoms and latency at T3 was also significant (β=.26, p<.05), but no other concurrent correlations were significant. One crossover effect was significant with depressive symptoms atT1 predicting increased sleep start variability at T2 (β=.25, p<.05). The concurrent relationship at T2 was significant (β=.28, p=.01), with higher depressive symptoms being significantly associated within increased sleep start variability. There was one concurrent, positive, correlation between depressive symptoms and sleep efficiency at T2 (β=.24, p<.05) There was one predictive effect, such that depressive symptoms at T1predicted increased subject sleep complaints at T2 (β=.26, p<.01). There were also positive and significant concurrent association between depressive symptoms and subjective sleep problems at all three-time points (all p's<.01)	Self-reported bias; small sample size
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Kono et al. (2015)[24]	Cross-Sectional	Hokkaido University, Japan	International students from the college N=473, 40.9% female; age <30 years old=58.3%	Subjects assessed by questionnaires via internet survey; Authors created sleep measurement questionnaire and also used CES-D	The unadjusted odds ratios suggested that 12 variables had statistically significant associations with depressive symptoms: quality of sleep (adjusted OR 7.35; 95 % CI 3.87–14.0)	Self-reported bias; Cross-sectional study; A portion of the population is above 30 years old

Continuation Table 2.

Peltzer & Pengpid (2015)[25]	Cross-Sectional	Universities in different countries	Undergraduate students from the universities N=20.222, 58.5% female; Mean age=20.8±2.8	Subjects assessed by questionnaires; Authors created sleep measurement questionnaire and used CES-D	Depression symptoms (moderate/severe) was associated with nocturnal sleep problems AOR (95% CI) 2.61 (2.29–2.99) p<0.001	Self-report bias; Cross-sectional study; recall bias; only those students reporting severe or extreme sleeping problems were included,
Fatima et al. (2016)[26]	Cross-Sectional	Mater–University of Queensland Study of Pregnancy, Australia	Offspring with 21 years old N=3,778, 52.6% female; Mean age=20.60±0.86	Subjects assessed by questionnaires; PSQI and CES-D	depression had a impact on poor sleep quality in males (OR 1.15; 95% CI 1.12-1.18) and females (OR 1.11; 95% CI 1.08-1.13)	Self-report bias; Cross-sectional study; Shortened version of PSQI used
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Kabrita & Hajjar-Muça (2016)[27]	Cross-Sectional	Six private and public universities, Lebanon	Undergraduate students from the universities N=440, 50.6% female; Mean age=19.85±1.51	Subjects assessed by questionnaires; PSQI and CES-D	In females, wakeup time on weekdays, but not weekends, was negatively correlated with CES-D score (r=-0.168, p<0.05), as was the average weekday sleep duration (r=-.221, p<0.01). No significant correlation between these sleep parameters and CES-D was observed in males.	Self-reported bias; Cross-sectional study
Pensuksan et al. (2016)[28]	Cross-Sectional	One autonomous university, Thailand	Undergraduate students from the university N=1055, 76.2% female; Mean age=20.17±1.22	Subjects assessed by questionnaires; PSQI and DASS-21	Poor sleep quality was statistically significantly associated with symptoms of depression (r=0.34; p<0.001)	Self-reported bias; Cross-sectional study
Supartini et al. (2016)[29]	Cross-Sectional	Kyushu University, Japan	Students in the mentioned university N=1992, 30.5% female; Mean age=18.4±1.10	Subjects assessed by questionnaires; PSQI and CES-D	Depressive symptoms were significantly associated with bedtime (p=0.01), sleep-onset latency (p<0.001), and poor sleep quality (p<0.001); multivariate-adjusted OR of depression for bedtime of later than 01:30 versus 23:30 or earlier was 1.59 (95% CI: 1.04–2.44) Sleep-onset latency > 30 minutes was significantly associated with an increased prevalence of depressive symptoms (OR=1.53; 95% CI: 1.22–1.93). Poor sleep quality was significantly associated with an increased prevalence of depressive symptoms in age and sex adjusted model (OR=2.49; 95% CI: 2.02–3.06)	Self-report bias; Cross-sectional study; Shortened version of PSQI used
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Bhandari et al. (2017)[30]	Cross-Sectional	Undergraduate campuses in Kathmandu and Chitwan, Nepal	Undergraduate students in the mentioned campuses N=937, 54.6% female; Mean age=21.01±2.18	Subjects assessed by questionnaires; PSQI and PHQ-9	Mediation of association between sleep quality and depressive symptoms by internet addiction was statistically significant: 16.5% of the indirect effect of sleep quality on depressive symptoms	Self-reported bias; Cross-sectional study
Lau et al. (2017)[31]	Longitudinal	University of Hong Kong, China	Undergraduate students in the mentioned university N=1628, 67.6% female; Mean age=20.90±2.66	Subjects assessed by questionnaires in 3 different period times; PSQI and DASS-21	There was no significant relationship between poor sleep quality at Wave 1 and any of the three mood variables at Wave 2 for the morning-type group. In both the evening-type and intermediate-type groups, on the contrary, poor sleep quality at Wave 1 positively predicted higher levels of depressive mood, at Wave 2 (β =.424, p<.001/ β=.260, p<.001)	Self-report bias; Adaptation bias in instruments

Continuation Table 2.

Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Mokros et al. (2017)[32]	Cross-Sectional	Faculty of Medicine at Medical University of Lodz, Poland	Students from the mentioned university N=140; Mean age=22.34±1.37; gender not characterized	Subjects assessed by questionnaires; PSQI and BDI-II	Sleep quality predicted depressive symptoms independently of the investigated personal dispositions among students [GML model – BDI/PSQI: Step 1: R 2=0.151, df=3, F=9.098, p<0.001 – β=0.393 (0.237-0.549) p<0,001; Step 2: R 2=0.260, df=5, F=10.636, p<0.001 - β=0.396 (0.245-0.547) p<0,001; Step 3: R 2=0.275, df=6, F=9.519, p<0.001 - β=0.380 (0.228-0.531) p<0,001]	Self-reported bias; Cross-sectional study; Small sample size; selection bias; no gender data.
Seun-Fadipe & Mosaku (2017)[2]	Cross-Sectional	Obafemi Awolowo University, Nigeria	Students from the mentioned university N=505, 49.5% female; Mean age=21.90±2.70w	Subjects assessed by questionnaires; PSQI and HADS	Depression has significant association with poor sleep quality (p<.001). Pearson correlation analysis showed a positive correlation between global sleep quality score and depression score on HADS (r=0.387, p<.001)	Self-reported bias; Cross-sectional study; Recall bias
Tao et al. (2017)[7]	Cross-Sectional	College in Anhui, China	Students in the mentioned college N=4747, 58.4% female; Mean age=19.24±1.41	Subjects assessed by questionnaires; PSQI, CES-D	Problematic mobile phone use and sleep and sleep quality are independently associated with mental health symptoms. Poor sleep quality was positively correlated with depressive symptoms (OR: 4.97, 95% CI: 3.99–6.19w)	Self-reported bias; Cross-sectional study
Study	Design	Setting	Population	Interventions and Outcome measures	Results	Limitations
Wallace et al. (2017)[4]	Longitudinal	Three colleges in Minnesota, United States of America	Students from the mentioned colleges N=441, 68% female; Mean age=22.80±5.00	Subjects assessed by questionnaires; PSQI and CES-D (10 question version)	Analysis examining sleep deprivation, the final model shows that age (b=−0.02, p<.05), race (b=0.22, p<.05), episodic and chronic depressive symptoms (b L1=0.47, p<.0001; b L2=0.81, p<.0001), and sleep quantity (b L1 =−0.21, p<.0001; b L2=−0.24, p<.0001) were all significant predictors. Both the L1 and L2 effects for depressive symptoms were significantly predictive of sleep deprivation, suggesting that both episodic and chronic depressive symptoms were uniquely associated with sleep deprivation, although chronic depressive symptoms exhibited the larger effect. Fewer hours of sleep than usual (L1) and fewer hours of sleep across the 2 years (L2) were both associated with increased sleep deprivation.	Self-reported bias; Cross-sectional study; Small sample size; selection bias

pressures and cultural norms, reaction, and coping mechanisms to life stresses, in addition to biological factors[27]. Interestingly one study revealed that poor sleep quality is related to depressive symptoms in males, but stress in females[19]. Existing studies do not deliver information on whether gender difference remains significant after concurrently considering the impact of other socio-demographic, lifestyle factors, and affective disorders. The gender difference in sleep problems is mostly attributed to the physiologic differences, the importance of affective disorders and socioeconomic inequalities, indicating these may be the pathway variables through which gender disparity in poor sleep is displayed[26].

Genetic Factors

A longitudinal study found that individuals carrying 2 alleles with the low-polymorphism of the serotonin transporter gene 5-HTTLPR reported more depressive mood in the presence of a persistent pattern of short nocturnal sleep. Thus, exposure to chronic levels of insufficient or disrupted sleep may manifest a preexisting vulnerability in genetically susceptible individuals[5]. Other longitudinal study found that the number of G alleles in rs11932595, from the CLOCK gene, is positively associated with self-reported sleep quality, suggesting that polymorphisms within this gene may be considered a factor[12].

Year of study and College

Some authors found that increasing year of study in university or college predicted good sleep quality. It indicates that students in later years may have developed better coping strategies for their academic life[1,21,29]. There is also evidence that poor sleep quality and depression is common among medical students[32]. Thus the demands over specific students in different schools may also contribute to influence the first.

Use of technology

With the recent technological advancement, a new factor may have appeared as a potential influencer in the relationship between sleep and depression. This is evident when studies prior to the technological boom of electronic devices didn't account this variable[33,34]. Some authors found that waking up to answer one's phone predicted lower sleep quality, which in turn predicted depression[18]. In another study, depression acted as a mediator between smartphone overuse and poor sleep quality. The mechanisms behind this phenomenon may be due to probably affecting sleep architecture, alteration of melatonin release by influence of bright light, displacement of sleep, influence of electromagnetic fields emitted from the devices on brain activity, physical discomfort during its usage or because of cognitive, emotional or physiological arousal[22].

Chronotype

As individuals may be classified as either morning-types, intermediate types or evening-types, some studies report that circadian preferences may have an important role in the connection between sleep and depression[10,31,32]. The literature reveals mixed results concerning this factor. Several studies settle that an evening chronotype is linked to poor sleep quality among young adults and college students[32]. Some authors support that the prevalence of depressive symptoms was significantly higher among students with a late bedtime and prolonged sleep-onset latency[20,29]. One longitudinal study suggests that morning-type chronotype has a protective effect against the potential harm of poor sleep on optimism, yet not against the damage of pessimism on sleep quality[31]. However, one study found that 40% of evening-types were classified as having good sleep characteristics and did not generally differ on the sleep characteristics relative to most of morning-types, who reported good sleep. The authors propose that perceived morningness-eveningness may not account to influence sleep quality[10].

Regarding weekend, one study suggests that students tend to maintain similar sleep wake patterns across the week and weekend[10]. However, other study reported that students sleep significantly longer in weekends, mainly females[27].

Sleep Quantity

The mechanisms underlying the association between bedtime and depression remain unknown as some authors haven't found a consistent relation between sleep duration and depression[29]. However, some authors support that short sleep duration is associated with increased depressive symptoms in a U-shaped relationship20. Despite these contradictory results, some authors found that there are significant improvements in several sleep patterns across the transition from high-school to college: increases in sleep efficiency, sleep minutes, and subjective sleep quality after this transition[23].

Studies Limitations

Regarding the cross-sectional studies, the studies were limited mainly by their nature. In this case, causality is impossible to be established[7]. As the questionnaires used were mostly self-reported, being a subjective measure, recall bias must be accounted. Confirmation of these results using objective measurements, such as actigraphy monitoring throughout the day, would be desirable[8,20].

In the case of longitudinal studies which used actigraphy, sample size is one of the most significant limitations. The validity of the usage of this instrument is yet to be determined[12].

The students who were able to participate in these studies were expected to maintain a healthy lifestyle and relatively good mental health. Consequently, the students who could not participate in the studies might be likely to have more severe problem and become socially withdrawn with problems such as sickness and absenteeism in the future. Such high-risk students should have been included in the studies[20].

Other compensatory sleep habits haven't been accounted for, such as napping or nodding in the classroom[20]. Also, the weekend period was only considered in two of the studies[10,27], which may have an important role in the characteristics in the subject's sleep phase[21].

The presence of mental health problems and poor sleep quality was assessed by standardized clinical questionnaires. However, these measures are not equivalent to clinical diagnoses[35], and these instruments have their own limitations. For example, PSQI may underestimate the outcomes of sleep quality[26] and both CES-D and DASS-21 instruments measure short- term depressive mood, therefore the outcome may not reproduce long-term associations that would result in clinical depression[6].

LIMITATIONS

This systematic review has its own limitations. First, it only used one search engine and only searched for studies written in English. It is possible that a great quantity of relevant articles has been missed out and its results could bring a different perspective. Second, the focus on depression and sleep is not totally realistic, since depression and sleep quality are influenced by many other variants such as stress, anxiety or physical health, which in term may have an important role in their relationship[16,35-37]. This indicates that the relationship between sleep and depression is a complex phenomenon and its approach by simplifying the variables may not represent the reality of the problem. Third, this review focused in a very specific population with habits and pressures that may not be seen in the general population, thus the variables may be influenced by other mechanisms not applied to college students. For example,

university students have later sleep and wake times, higher rates of daytime sleepiness, and physical and mental health complaints, than the general population[37]. Fourth, the impact of socioeconomic and cultural factors was not deeply explored in this review as it includes studies from developed and under development countries.

CONCLUSION

It is becoming consistent that self-reported low sleep quality is a predictor of depression or depressive symptoms, at least regarding the young adults that attend universities and colleges. However, it is important to acknowledge that sleep disturbances and depression have a bidirectional association, so depression also influences sleep, as a recent meta-analysis on older adults found[38]. Defended by many of the authors, and demonstrated by an experimental study, an intervention in sleep hygiene can have benefic effects on reducing depression among the students. The institutions should recognize the importance of sleep hygiene and educate its population of its consequences, having in consideration that this population is probably unaware of this problem and it's late night culture.

As the understanding of the complexity of sleep is becoming clearer, also pragmatic interventions should result from its study. In this direction, some research has already been conducted, demonstrating that cognitive behavioral self-help programs can improve sleep and depressive symptoms[11]. The research on this field still has its challenges concerning the measurements. However, with the uprising in the miniaturization of technology, the actigraphy may become cheaper and easy to use and so giving the possibility of a profound study, among others, of the sleep habits in the human populations.

Finally, there is a lack of evidence in how the different grades of depression affect sleep quality and vice versa. This could possibly demonstrate if sleep affects the progression of depression's severity, if there is a correlation between the worsening of the quality of sleep and depression stage, or how different types of depression relate to sleep.

Funding

None of the authors had any direct or indirect funding in support of this study.

CONFLICT OF INTEREST

The authors have no financial relationships, or conflicts of interest to disclose.

REFERENCES

1. Lemma S, Gelaye B, Berhane Y, Worku A, Williams MA. Sleep quality and its psychological correlates among university students in Ethiopia: a cross-sectional study. BMC Psychiatry. 2012;12:237.
2. Seun-Fadipe CT, Mosaku KS. Sleep quality and psychological distress among undergraduate students of a Nigerian university. Sleep Health. 2017;3(3):190-4.
3. Kenney SR, Lac A, Labrie JW, Hummer JF, Pham A. Mental health, sleep quality, drinking motives, and alcohol-related consequences: a path-analytic model. J Stud Alcohol Drugs. 2013;74(6):841-51.
4. Wallace DD, Boynton MH, Lytle LA. Multilevel analysis exploring the links between stress, depression, and sleep problems among two-year college students. J Am Coll Health. 2017;65(3):187-96.
5. Carskadon MA, Sharkey KM, Knopik VS, McGeary JE. Short sleep as an environmental exposure: a preliminary study associating 5-HTTLPR genotype to self-reported sleep duration and depressed mood in first-year university students. Sleep. 2012;35(6):791-6.
6. Wilson KT, Bohnert AE, Ambrose A, Davis DY, Jones DM, Magee MJ. Social, behavioral, and sleep characteristics associated with depression symptoms among undergraduate students at a women's college: a cross-sectional depression survey, 2012. BMC Womens Health. 2014;14:8.
7. Tao S, Wu X, Zhang Y, Zhang S, Tong S, Tao F. Effects of Sleep Quality on the Association between Problematic Mobile Phone Use and Mental Health Symptoms in Chinese College Students. Int J Environ Res Public Health. 2017;14(2). Pii: E185.
8. Regestein Q, Natarajan V, Pavlova M, Kawasaki S, Gleason R, Koff E. Sleep debt and depression in female college students. Psychiatry Res. 2010;176(1):34-9.
9. Wong ML, Lau EY, Wan JH, Cheung SF, Hui CH, Mok DS. The interplay between sleep and mood in predicting academic functioning, physical health and psychological health: a longitudinal study. J Psychosom Res. 2013;74(4):271-7.
10. Tavernier R, Willoughby T. Are all evening-types doomed? Latent class analyses of perceived morningness-eveningness, sleep and psychosocial functioning among emerging adults. Chronobiol Int. 2014;31(2):232-42.
11. Trockel M, Manber R, Chang V, Thurston A, Taylor CB. An e-mail delivered CBT for sleep-health program for college students: effects on sleep quality and depression symptoms. J Clin Sleep Med. 2011;7(3):276-81.
12. Vanderlind WM, Beevers CG, Sherman SM, Trujillo LT, McGeary JE, Matthews MD, et al. Sleep and sadness: exploring the relation among sleep, cognitive control, and depressive symptoms in young adults. Sleep Med. 2014;15(1):144-9.
13. Moo-Estrella J, Pérez-Benítez H, Solís-Rodríguez F, Arankowsky-Sandoval G. Evaluation of depressive symptoms and sleep alterations in college students. Arch Med Res. 2005;36(4):393-8.
14. Carney CE, Edinger JD, Meyer B, Lindman L, Istre T. Daily activities and sleep quality in college students. Chronobiol Int. 2006;23(3):623-37.
15. Augner C. Associations of subjective sleep quality with depression score, anxiety, physical symptoms and sleep onset latency in students. Cent Eur J Public Health. 2011;19(2):115-7.
16. Matsumoto Y, Toyomasu K, Uchimura N. Assessment of physical and mental health in male university students with varying sleep habits. Kurume Med J. 2011;58(4):105-15.
17. Benitez A, Gunstad J. Poor sleep quality diminishes cognitive functioning independent of depression and anxiety in healthy young adults. Clin Neuropsychol. 2012;26(2):214-23.
18. Adams SK, Kisler TS. Sleep quality as a mediator between technology-related sleep quality, depression, and anxiety. Cyberpsychol Behav Soc Netw. 2013;16(1):25-30.
19. Lovell GP, Nash K, Sharman R, Lane BR. A cross-sectional investigation of depressive, anxiety, and stress symptoms and health-behavior participation in Australian university students. Nurs Health Sci. 2015;17(1):134-42.
20. Matsushita M, Koyama A, Ushijima H, Mikami A, Katsumata Y, Kikuchi Y, et al. Sleep duration and its association with sleepiness and depression in "ronin-sei" preparatory school students. Asian J Psychiatr. 2014;9:61-6.
21. Asaoka S, Komada Y, Aritake S, Morita Y, Fukuda K, Inoue Y. Effect of delayed sleep phase during university life on the daytime functioning in work life after graduation. Sleep Med. 2014;15(9):1155-8.
22. Demirci K, Akgönül M, Akpinar A. Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. J Behav Addict. 2015;4(2):85-92.
23. Doane LD, Gress-Smith JL, Breitenstein RS. Multi-method assessments of sleep over the transition to college and the associations with depression and anxiety symptoms. J Youth Adolesc. 2015;44(2):389-404.
24. Kono K, Eskandarieh S, Obayashi Y, Arai A, Tamashiro H. Mental Health and Its Associated Variables Among International Students at a Japanese University: With Special Reference to Their Financial Status. J Immigr Minor Health. 2015;17(6):1654-9.
25. Peltzer K, Pengpid S. Nocturnal sleep problems among university students from 26 countries. Sleep Breath. 2015;19(2):499-508.
26. Fatima Y, Doi SA, Najman JM, Mamun AA. Exploring Gender Difference in Sleep Quality of Young Adults: Findings from a Large Population Study. Clin Med Res. 2016;14(3-4):138-44.

27. Kabrita CS, Hajjar-Muça TA. Sex-specific sleep patterns among university students in Lebanon: impact on depression and academic performance. Nat Sci Sleep. 2016;8:189-96.
28. Pensuksan WC, Lertmaharit S, Lohsoonthorn V, Rattananupong T, Sonkprasert T, Gelaye B, et al. Relationship between Poor Sleep Quality and Psychological Problems among Undergraduate Students in the Southern Thailand. Walailak J Sci Technol. 2016;13(4):235-42.
29. Supartini A, Honda T, Basri NA, Haeuchi Y, Chen S, Ichimiya A, et al. The Impact of Sleep Timing, Sleep Duration, and Sleep Quality on Depressive Symptoms and Suicidal Ideation amongst Japanese Freshmen: The EQUSITE Study. Sleep Disord. 2016;2016:8737654.
30. Bhandari PM, Neupane D, Rijal S, Thapa K, Mishra SR, Poudyal AK. Sleep quality, internet addiction and depressive symptoms among undergraduate students in Nepal. BMC Psychiatry. 2017;17(1):106.
31. Lau EY, Hui CH, Lam J, Cheung SF. Sleep and optimism: A longitudinal study of bidirectional causal relationship and its mediating and moderating variables in a Chinese student sample. Chronobiol Int. 2017;34(3):360-72.
32. Mokros Ł, Witusik A, Michalska J, Łężak W, Panek M, Nowakowska-Domagała K, et al. Sleep quality, chronotype, temperament and bipolar features as predictors of depressive symptoms among medical students. Chronobiol Int. 2017;34(6):708-20.
33. Taub JM. Behavioral and psychophysiological correlates of irregularity in chronic sleep routines. Biol Psychol. 1978;7(1-2):37-53.
34. Pilcher JJ, Ginter DR, Sadowsky B. Sleep quality versus sleep quantity: relationships between sleep and measures of health, well-being and sleepiness in college students. J Psychosom Res. 1997;42(6):583-96.
35. Feng Q, Zhang QL, Du Y, Ye YL, He QQ. Associations of physical activity, screen time with depression, anxiety and sleep quality among Chinese college freshmen. PLoS One. 2014;9(6):e100914.
36. Wu X, Tao S, Zhang Y, Zhang S, Tao F. Low physical activity and high screen time can increase the risks of mental health problems and poor sleep quality among Chinese college students. PLoS One. 2015;10(3):e0119607.
37. Samaranayake CB, Arroll B, Fernando AT, 3rd. Sleep disorders, depression, anxiety and satisfaction with life among young adults: a survey of university students in Auckland, New Zealand. N Z Med J. 2014;127(1399):13-22.
38. Bao YP, Han Y, Ma J, Wang RJ, Shi L, Wang TY, et al. Cooccurrence and bidirectional prediction of sleep disturbances and depression in older adults: Meta-analysis and systematic review. Neurosci Biobehav Rev. 2017;75:257-73.