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Supplemental Table 1

Prevalence of sleep disturbances in Chinese university students: a comprehensive meta-analysis

Running head: Sleep disturbances in university students

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Conflict of Interests

The authors declare no conflict of interest.

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Author contributorship

Study Design: Lu Li, Yuan-Yuan Wang, Shi-Bin Wang, Yu-Tao Xiang. Data collection: Lu Li, Yuan-Yuan Wang, Shi-Bin Wang. Analysis and interpretation of data: Lu Li, Yuan-Yuan Wang, Shi-Bin Wang, Ling Zhang, Lin Li. Drafting of the manuscript: Lu Li, Yuan-Yuan Wang, Shi-Bin Wang, Yu-Tao Xiang. Critical revision of the manuscript: Dan-Dan Xu, Chee H. Ng, Gabor S. Ungvari, Xiling Cui, Zhao-Min Liu, Spencer De Li, Fu-Jun Jia. Approval of the final version for publication: All the authors.

Summary

This is a meta-analysis of the pooled prevalence of sleep disturbances and its associated factors in Chinese university students. English (PubMed, PsycINFO, Embase) and Chinese (SinoMed, Wan Fang Database and Chinese National Knowledge Infrastructure) databases were systematically and independently searched from inception until August 16, 2016. The prevalence of sleep disturbances was pooled using random-effects model. Altogether 76 studies involving 112,939 university students were included. The overall pooled prevalence of sleep disturbances was 25.7% (95% CI: 22.5%-28.9%). When using the screening scales Pittsburgh Sleep Quality Index, Athens Insomnia Scale and Self-Rating Sleeping State Scale, and the diagnostic criteria of the Chinese Classification of Mental Disorders (Second Edition), the pooled prevalence of sleep disturbances was 24.1% (95% CI: 21.0%-27.5%) and 18.1% (95% CI: 16.4%-20.0%), respectively. The percentage of students dissatisfied with sleep quality and those suffering from insomnia symptoms was 20.3% (95% CI: 13.0%-30.3%) and 23.6% (95% CI: 18.9%-21.9%), respectively. Subgroup analyses revealed that medical students were more vulnerable to have sleep disturbances than other student groups. There was no significant difference between males and females, and across geographic locations. Sleep disturbances are common in Chinese university students. Appropriate strategies for prevention and treatment of sleep disturbances in this population need greater attention.

Key words: sleep disturbances, meta-analysis, university students, China

Introduction

Sleep disturbances encompassing a wide range of sleep complaints, such as difficulty in initiating sleep (DIS), difficulty in maintaining sleep (DMS), early morning awakenings (EMA), non-restorative sleep (NRS) and poor sleep quality, is a major health problem (Kalmbach et al., 2017, Liu et al., 2016, Zhang and Wing, 2006). Due to discrepancy in definition, criteria and timeframe, prevalence of sleep disturbances varies greatly across studies. For example, the prevalence of sleep disturbances as measured by the presence (yes/no) of any sleep complaint (DIS, DMS, EMA or NRS) ranges between 1.6% and 76.3% in the general population (Rocha et al., 2002, Ohayon et al., 1997a, Ohayon and Smirne, 2002, Ohayon and Paiva, 2005, Ohayon and Sagales, 2010, Kim et al., 2000). In contrast, the prevalence of sleep disturbances as defined by dissatisfaction with sleep quality or quantity, or subjective poor sleep ranges between 7.0% and 50.5% (Ohayon and Smirne, 2002, Ohayon and Paiva, 2005, Ohayon and Partinen, 2002, Ohayon et al., 1997b, Ohayon, 1996, Nowicki et al., 2016). Using screening instruments such as the Pittsburgh Sleep Quality Index (PSQI) or the Athens Insomnia Scale (AIS), the prevalence of sleep disturbances ranges between 25.3% and 38.2% (Madrid et al., 2017, Paparrigopoulos et al., 2010, Soldatos et al., 2005). The prevalence assessed by using the criteria of the Diagnostic and Statistical Manual of Mental Disorders-IV (DSM-IV) or the International Classification of Sleep Disorders (ICSD) ranges between 1.6% and 11.7% (Ohayon and Hong, 2002, Ohayon et al., 1997a, Ohayon and Paiva, 2005, Ohayon and Smirne, 2002, Ohayon and Partinen, 2002).

Poor sleep quality is associated with negative health outcomes, such as fatigue, low energy, difficulty in concentration, mood disturbances, cognitive impairment and poor work performance (Ratcliff and Van Dongen, 2009, Roth, 2007, Zhang et al., 2016). In addition, poor sleep quality is also associated with certain medical conditions (e.g., fibromyalgia, arthritis/rheumatism, back problems, migraine, heart disease and cancer) (Baker et al., 2017, Belt et al., 2009, Javaheri and Redline, 2017, Kim et al., 2016, Galiano et al., 2017) and psychiatric disorders (Ye et al., 2016, Baglioni et al., 2011).

University students, who are transitioning from adolescence to adulthood, usually experience numerous challenges, such as adapting to new social

situations, leaving home, coping with high academic and social pressures, and erratic living schedules, all of which could increase the risk of sleep disturbances (Peltzer and Pengpid, 2015). Previous studies found variable rates of sleep disturbances in this population. The prevalence of sleep disturbances ranges from 3.0% to 74.2% worldwide, for instance, 3.0% in Thailand (Mohammadbeigi et al., 2016), 9.8% in Lebanon (Younes et al., 2016), 22.5% in the USA (Gress et al., 2015), 33.3% in Japan (Supartini et al., 2016), 74.2% in Saudi Arabia (Siddiqui et al., 2016), 51.8 % in Chile (Velez et al., 2013), and 61.7% in Iran (Mohammadbeigi et al., 2016). Apart from different sampling methods and geographic locations, the use of different instruments, such as the PSQI (Mohammadbeigi et al., 2016), the Insomnia Severity Index (ISI) (Gress et al., 2015) and non-quantitative measures (Peltzer and Pengpid, 2015) could account for such variation in prevalence. Furthermore, the patterns of sleep disturbances are associated with the students' demographic characteristics, lifestyle factors, grade point average (GPA) (William et al., 2001, Entsarkamel et al., 2015, Azad et al., 2015), alcohol, tobacco and drug use (Bertazzo-Silveira et al., 2016), and increased risk of suicidality (Bozzay et al., 2016). Identifying patterns of sleep disturbances and their association with specific demographic and clinical variables may help to develop appropriate treatment guidelines and allocate appropriate health resources. Moreover, sociocultural factors greatly influence the patterns of sleep disturbances (Gureje et al., 2007, Ohayon and Partinen, 2002), thus it is necessary to examine sleep disturbances in different populations and societies separately.

There is currently no published meta-analysis of the prevalence of sleep disturbances in Chinese university students. This meta-analysis thus examined the pooled prevalence of sleep disturbances in Chinese university students using both English and Chinese databases.

Methods

Search strategies

PubMed, EMBASE, PsycINFO, SinoMed, WanFang and Chinese National Knowledge Infrastructure (CNKI) were systematically and independently searched by two reviewers from inception to August 16, 2016. This included

publications/journals in these databases in both English and Chinese languages. The following search terms were used: ('China' or 'Chinese') and ('insomnia' or 'sleep symptoms' or 'sleep disorders' or 'sleep quality' or 'sleep disturbance' or 'sleep problem' or 'sleep time' or 'sleep duration' or 'sleep habit' or 'sleep pattern') and ('prevalence' or 'epidemiology survey' or 'cross-sectional study') and ('university students' or 'college students' or 'undergraduate students' or 'adolescents' or 'young adults'). We also searched the reference lists of the selected papers to avoid missing certain records.

Study selection

Original quantitative studies which fulfilled the following criteria were included in the meta-analysis: (1) Cross-sectional epidemiological study conducted in undergraduate students in mainland China, Hong Kong, Macao and Taiwan; (2) reported prevalence of sleep disturbances; (3) having a sample size>500. Exclusion criteria were: (1) case studies, (2) surveys based on convenience-sampling method or no sampling information (3) no information on response rate. Two reviewers (LL and YYW) checked the titles, abstracts, and full-texts of the initial search results independently. Any discrepancies emerged in these procedures were discussed and resolved by involving a third reviewer (SBW).

Quality evaluation

Two reviewers (LL and YYW) independently assessed the methodological quality of the studies using a quality assessment tool consisting of 8 items in terms of sampling, measurement and analysis; Supplementary Table 1.). The item scores range between 0 and 8, with a score of 7–8 as high quality, 4–6 as moderate quality and 0–3 as low quality (Yang et al., 2016). Disagreements between the two reviewers were resolved by discussing with a third reviewer (SBW).

Data extraction

Data was independently extracted by two reviewers (LL and YYW) and was checked by a third reviewer (SBW). The following information was extracted and tabulated: study site and survey period, geographic location, sampling methods,

medical or non-medical students, grade, age, proportion of males, sample size, response rate, assessment instruments and cut-off of sleep disturbances related to PSQI, the prevalence of sleep disturbances, timeframe of sleep disturbances (past 1-2 weeks, past month, past year) and quality assessment.

Statistical analyses

The Stata software, Version 12.0 (Stata Corporation, College Station, Texas, USA) and the Comprehensive Meta-Analysis software, Version 2 (Biostat Inc., Englewood, New Jersey, USA) were used to perform the meta-analysis. The I^2 statistic was used to evaluate heterogeneity of the studies with I^2 values greater than 50% indicating heterogeneity (Higgins et al., 2003). The results of the studies were combined using random-effects model; prevalence with 95% confidence intervals (CIs) were used for analysis. The funnel plot and Egger's test were used to assess publication bias (Egger et al., 1997). The 'trim-and-fill' method was used to estimate the number of missing studies using random-effects model. Sensitivity analysis was conducted by removing each study individually to evaluate the quality and consistency of the results. All analyses were two tailed, with alpha set at 0.05.

Results

Search results, studies characteristics and quality assessment

Figure 1 shows the flow chart of the search and selection progress. In total 3,114 records were collected in the initial search. After removing the duplicates, 2,239 papers were screened by title and abstract. After full-text review of the remaining 364 studies, 288 studies were excluded due to the following reasons: duplicate publications (n=36), no data on prevalence (n=107) or sampling information (n=25), sample size<500 (n=69), no full text (n=11), no data on undergraduates (n=21) and no response rate (n=19) reported. Finally, 76 studies (11 in English and 65 in Chinese) with 112,939 university students were included for analyses, of which 72 were conducted in mainland China, one in Hong Kong and three in Taiwan.

Table 1 shows the basic characteristics of the studies. Studies were published from 1997 to 2016; 81.5% appeared after 2010 and 33 studies reported the

survey period that ranged from 2006 to 2015. Most studies assessed sleep disturbances using the PSQI, one study used the Self-Rating Sleeping State Scale (SRSS), two used the AIS, and one used the Chinese Classification of Mental Disorders - Second Edition (CCMD-II). Thirteen studies used non-quantitative scales, of which 11 assessed sleep disturbances using standardized questions, i.e., "Are you satisfied with your sleep quality in the past month?"; 2 assessed sleep disturbances using other questions, i.e., "Do you have DIS, DMS and EMA?". These standardized questions measured sleep disturbances with "yes/no" answers. All studies were rated as of "moderate quality". The mean score of the quality assessment was 5, ranging from 4 to 6.

Sleep prevalence

Figure 2 shows the forest plot of the prevalence of sleep disturbances. The prevalence estimates of sleep disturbances across the 76 studies covering 112,939 university students ranged from 1.90% to 68.6%; the pooled prevalence was 25.7% (95% CI: 22.5%-28.9%). I^2 was 99.5% indicating that heterogeneity characterized the studies of the meta-analysis.

Subgroup analyses

Table 2 presents the pooled prevalence of sleep disturbances measured with different screening or diagnostic instruments. There was significant difference in sleep disturbances between studies with different instruments ($Q=12.8$, $p=0.005$) and between different timeframe of sleep disturbance ($Q=217.6$, $p<0.001$). When using the screening tools (PSQI, AIS, SRSS) and the diagnostic tool (CCMD-II) the pooled prevalence was 24.1% (95% CI: 21.0%-27.5%, $I^2=99.2\%$, $p<0.001$) and 18.1% (16.4%-20.0%, $I^2=0$), respectively. The prevalence of sleep disturbances when defined as dissatisfaction with sleep quality or suffering from predominant complaints (DIS, DMS, EMA or NRS) was 20.3% (95% CI: 13.0%-30.3%, $I^2=99.4$, $p<0.001$) and 23.6% (95% CI: 18.9%-29.0%, $I^2=92.2\%$, $p<0.001$), respectively. The prevalence of sleep disturbances in the past 1-2 weeks, past month, and past year was 15.7% (95% CI: 5.6%-36.7%, $I^2=98.3\%$), 23.9% (95% CI: 21.0%-27.2%, $I^2=99.2\%$) and 1.9% (95% CI: 1.4%-2.6%, $I^2=0$), respectively. The pooled prevalence of sleep

disturbances in 59 studies with 88,432 students using the PSQI was 23.9% (95% CI: 20.8%-27.4%, I^2=99.0%). In order to examine the impact of moderating factors (sex, grade, medical or non-medical students, geographic distribution, survey year, sample size and different cut-off score related to PSQI) on the results, subgroup analyses were conducted (Table 2). There were no significant differences in the prevalence of sleep disturbances between male and female student (22.0% vs 24.9%,Q=1.2,p=0.25), between the northern and southern part of China (21.2% vs 23.9%, Q=0.8, p=0.36), between survey years (25.2% in 2006-2010 vs 25.7% in 2011-2015, Q=0.004, p=0.94), between grades (25.3% vs 22.2% vs 22.7% vs 22.8%, Q=0.6, p=0.88), and between students from rural and urban areas (22.9% vs 22.1%, Q=0.04, p=0.83). The prevalence of sleep disturbances was different across different PSQI cut-off values (47.2% vs. 26.3% vs. 21.1% vs. 15.5%, Q=49.6, p<0.001). Medical students (25.5%, 95% CI: 21.9%-29.6%) were more vulnerable to have sleep disturbances than non-medical students (19.0%, 95% CI: 15.1%-23.7%) (Q=4.6, p=0.031). The prevalence of sleep disturbances in studies with sample size >1000 (27.7%, 95% CI: 22.7%-33.3%) was significantly higher than in those with sample size of 500-1000 (20.8%, 95% CI: 17.2%-24.9%) (Q=4.3, p=0.036).

Publication bias

According to the results of visual funnel plot and the Egger's test publication bias was found, therefore the 'trim and fill' method was performed. Fifteen studies were missing and the recalculated prevalence of sleep disturbances according to the 'trim and fill' method was 27.7% (95% CI: 24.6%–30.9%).

Sensitivity analysis

When each study was sequentially excluded from each group, the recalculated combined results did not change significantly, which indicates that no individual study significantly influenced the overall results.

Discussion

This was the first meta-analysis of the pooled prevalence of sleep disturbances in Chinese university students. The prevalence of sleep disturbances in Chinese

university students was 25.7% (95% CI: 22.5%-28.9%), which is higher than the figures measured by standardized questions in a sample of 20,222 undergraduate university students from 26 countries (10.4%) (Peltzer and Pengpid, 2015). Peltzer et al. study measured the prevalence of nocturnal sleeping problems by the presence (yes/no) of any sleep complaint (DIS, DMS, or EMA). A recent systematic review found the pooled prevalence of insomnia of 18.5% in freshman university students worldwide (Jiang et al., 2015). Our finding is also significantly higher than the figure in the Chinese general population according to a recent meta-analysis (15.0%) with similar methodology (Cao et al., 2017). The comparisons above show that sleep disturbances are more common in Chinese university students.

In this study, there was significant difference in sleep disturbance rates between studies using different instruments. In the only study with the SRSS, the figure was 52.8%, which was significantly higher than in the other studies. The prevalence of sleep disturbances using the Chinese diagnostic criteria of CCMD-II (18.1%) was lower than those using screening tools. Furthermore, significant difference was found between results with different timeframes ($Q = 217.6$, $p < 0.001$). The prevalence of sleep disturbances in the past 1-2 weeks, past month, and past year was 15.7%, 23.9% and 1.9%, respectively. Only one study reported sleep disturbance in the past year (Xu et al., 2016). There was significant difference in prevalence of sleep disturbances between studies using different PSQI cut-off values ($Q = 49.6$, $p < 0.001$). The Chinese version of the PSQI has been validated in Chinese populations and several cut-off values have been used with satisfactory psychometric properties (Buysse et al., 1989, Tsai et al., 2005, Liu et al., 1996). It should be noted that the number of studies, sampling method and instruments were different across different subgroups, which may affect the findings to an uncertain extent.

In this study, no significant difference was found between male and female students ($Q = 1.2$, $p = 0.25$). The associations between gender and sleep disturbances have been controversial. For example, female students had a higher prevalence of sleep disturbances compared to male students in Peru and Pakistan (Sanchez et al., 2013, Surani et al., 2015), but the result was the opposite in Iran and Lebanon (Yazdi et al., 2016, Siddiqui et al., 2016), while no

significant gender difference was found in the US (Buboltz et al., 2001). In this study, medical students (25.5%) were more vulnerable to sleep disturbances than non-medical students (17.3%), which is consistent with previous findings (Shad et al., 2015). Heavy academic workload for medical students could lead to increased psychological stress, anxiety and sleep disturbances (Azad et al., 2015). No difference was found between students from rural and urban areas (22.9% vs. 22.1%, Q= 0.04, p= 0.83) and between different grades (Q= 0.6, p= 0.88). Presumably, this is largely due to the similar university environment and study demands faced by both rural and urban students. In addition, no significant difference was found in sleep disturbances between survey years (2006-2010 vs. 2011-2015) (Q= 0.004, p= 0.94), but the prevalence figures were significantly different between studies with sample size > 1000 (27.7%) and those with a sample of 500- 1000 (20.8%) (Q= 4.3, p= 0.036).

Since heterogeneity is unavoidable in meta-analysis of epidemiological surveys (Winsper et al., 2013, Long et al., 2014, Li et al., 2016b), substantial heterogeneity remained despite conducting subgroup analyses to controlling for a number of moderating factors. Due to limited information in the studies, additional sources of the heterogeneity, such as mental health and stress, could not be explored.

The strengths of this meta-analysis include the “moderate quality” of the studies, the use of probability sampling in all studies, and greater than 70% response rates in all but one study, indicating satisfactory representativeness of the study samples. The studies also covered different geographic areas in China, thus representing the university student population across China.

However, there are several limitations of the meta-analysis. First, most studies did not report the demographic data of non-responders. Second, substantial heterogeneity remained in subgroup analysis although this is unavoidable as mentioned above (Winsper et al., 2013, Long et al., 2014, Li et al., 2016b). Third, the timeframes of sleep disturbances (past 1-2 weeks，past month，past year or lifetime) were not clearly described in some studies.

In conclusion, sleep disturbances are common among Chinese university students, particularly in medical students. Heterogeneity characterized the studies in this meta-analysis. Contributing factors of sleep disturbances, such as

family history of sleep disorders and types of academic stress should be examined in future research. Also, objective measures on sleep including polysomnography should be considered in future studies. Since sleep disturbances are amenable to pharmacotherapy and psychological and behavioral interventions, health professionals should pay more attention to addressing sleep problems in this population.

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Figure1: Flowchart of the selection of studies

Figure 2: Forest plot of the prevalence of sleep disturbances in the college students (76 studies)

Figure 3: Funnel plot of publication bias for the 76 studies with available data on prevalence of sleep disturbances

Table 1. Characteristics of the included studies

No.	Principal author (year of publication)	Area	South or North of China	Time of the study	Sampling method	Medical student	Grade	Age (Mean±SD/ range)	Proportion of males (%)	Effective sample	Response rate	Instrument	Cut-off	Prevalence of sleep disturbance	Time frame	Quality Score
1	Cao et al., 2002	Xinjiang	N	NR	R	NR	1-4	21.32±2.56	50.07%	1,362	85.13%	PSQI	≥8	24.60%	LM	6
2	Cheng et al., 2012	Taiwan	-	2008	C	NR	1	NR	NR	4,318	83.52%	PSQI	≥6	57.04%	LM	6
3	Deng et al., 2014	Xinjiang	N	2013,3-4	C,S	Yes	1-4	NR	34.60%	552	92.77%	PSQI	≥8	42.93%	LM	6
4	Dong et al., 2013	Hebei	N	NR	C,R	Both	1-4	NR	22.53%	688	98.29%	PSQI	≥8	14.40%	LM	6
5	Fan et al., 2014	Shanghai	S	NR	C	No	1-3	17-25	71.99%	939	72.62%	PSQI	≥8	13.60%	LM	6
6	Feng et al., 2014	Hubei	S	2011	C,R,M	Both	1	18.9±0.9	57.40%	1,106	92.17%	PSQI	≥6	17.70%	LM	5
7	Feng et al., 2012	Xinjiang	N	2012,3	C,S	Yes	1-4	NR	33.96%	1,219	99.19%	PSQI	≥8	48.40%	LM	6
8	Geng et al., 2014	Jiangsu	S	NR	M,R	Both	1-4	NR	48.24%	1,194	97.87%	PSQI	≥8	23.80%	LM	5
9	Guo et al., 2016	Ningxia	N	NR	M,S	Both	1-4	NR	28.19%	777	99.13%	PSQI	≥8	36.60%	LM	5
10	Huang et al., 2007	Zhejiang	S	NR	C,S	Yes	1-3	NR	39.75%	1,024	94.81%	PSQI	≥8	34.00%	LM	5
11	Huang et al., 2013	Shanghai	S	2011,5-6	C,R,S	Both	1-5	20.6±1.4	47.76%	1,051	95.55%	PSQI	≥8	33.78%	LM	6
12	Huo et al., 2010	Neimenggu	N	NR	C,R	NR	1-4	22.17±1.48	38.16%	773	95.67%	PSQI	≥8	11.13%	LM	5
13	Lai et al., 2011	Jiangxi	S	2011	C,	Yes	1-3	20.3±1.31	47.33%	581	96.83%	PSQI	≥8	23.41%	LM	5
14	Lan et al., 2014	-	-	NR	C,R,S	NR	NR	NR	39.40%	599	97.24%	PSQI	≥8	14.69%	LM	5
15	Li et al., 2015a	Ningxia	N	NR	C,R,S	Yes	1-4	NR	49.14%	869	98.75%	PSQI	≥8	42.58%	LM	6
16	Li et al., 2015b	Henan	N	NR	C	Both	NR	NR	42.74%	503	91.45%	PSQI	≥7	22.50%	LM	5
17	Li et al., 2016	Liaoning	N	2014,8-9	C,S	NR	1-4	20.4±1.1	49.10%	1,053	96.52%	PSQI	≥8	14.70%	LM	5
18	Li ., 2009	Heilongjiang	N	NR	C	Yes	1-5	21±1.0	39.41%	4,808	90.50%	PSQI	≥8	25.90%	LM	5
19	Liao et al.,2016	Jilin	N	2014	C	Both	1-5	20.72±1.59	46.86%	956	94.04%	PSQI	≥8	13.95%	LM	6
20	Lin., 2015	Shanxi	N	NR	C,R	NR	NR	20.76±1.18	50.79%	1,012	100.00%	PSQI	≥8	8.10%	LM	5
21	Liu et al., 2011	Guizhou	S	2010,3-9	C,S	Both	1-4	20.52±1.52	40.40%	2,126	94.53%	PSQI	≥8	27.40%	LM	5
22	Liu and Zhang., 2013	Zhejiang	S	2007.11	C	Both	1-5	NR	40.60%	4,010	97.80%	PSQI	≥8	28.25%	LM	5
23	Liu et al., 1997	Shandong	N	NR	R,C	Yes	1-4	20.85±1.81	57.50%	560	93.33%	PSQI	≥8	13.93%	LM	6

24	Luo et al., 2014	Guangdong	S	NR	R	Both	1-4	19.0±2.0	53.61%	858	71.50%	PSQI	≥8	26.20%	LM	6
25	Peng et al., 2014	Guangdong	S	NR	C,R,S	Both	NR	20.19±1.69	47.53%	1,296	92.57%	PSQI	≥8	28.40%	LM	5
26	Shen et al., 2015	Jiangsu	S	2014,5	C	Both	1-3	20.5±1.1	56.41%	913	84.88%	PSQI	≥8	17.10%	LM	6
27	Sing et al., 2010	Hong Kong	-	NR	C	No	NR	21.01±1.77	45.40%	592	100.0%	PSQI	≥6	68.60%	LM	6
28	Shi et al., 2013	Jiangxi	S	2012,3	R	both	1-3	NR	43.76%	1,145	95.42%	PSQI	≥8	16.40%	LM	5
29	Shi et al., 2005	Guangdong	S	NR	C,R	Both	NR	20.74±1.27	48.62%	1,302	93.00%	PSQI	≥8	28.60%	LM	5
30	Chang et al., 2016	Taiwan	S	2014,3-4	C	NR	NR	19.23±1.01	40.89%	1,230	95%	PSQI	≥6	58.62%	LM	5
31	Sun et al., 2015	Jiangsu	S	2015,4	C,R,S	Both	1-3	17-21	57.89%	900	100.00%	PSQI	≥8	14.56%	LM	5
32	Tong et al., 2010	Jiangsu	S	NR	C,R	NR	1-4	20.45±1.51	39.02%	715	88.27%	PSQI	≥8	15.80%	LM	6
33	Wang et al., 2016a	Anhui	S	2015,5-6	C,R	No	1-4	20.1±1.3	58.25%	527	90.86%	PSQI	≥8	21.63%	LM	5
34	Wang et al., 2016b	Guangdong	S	NR	C,R,S	NR	1-4	NR	41.92%	1,312	93.71%	PSQI	≥8	33.60%	LM	5
35	Wang ., 2012	Hubei	S	NR	R	NR	NR	20.9±1.2	49.75%	796	94.76%	PSQI	≥8	17.84%	LM	5
36	Wang et al., 2016c	Neimenggu	N	2013	C	Yes	1–5	NR	27.28%	6,085	100%	PSQI	≥6	28.70%	LM	5
37	Wang et al., 2009	Hebei	N	2007	C,R	Yes	1-3	17-21	38.73%	710	96.99%	PSQI	≥8	15.20%	LM	5
38	Wang et al., 2008	Hainan	S	2006,10	C,R	Yes	1-5	21.07±1.84	46.10%	551	91.83%	PSQI	≥8	21.42%	LM	5
39	Wang et al., 2014a	Hainan	S	2013,5-6	M,R	NR	1-5	20.6±1.4	34.69%	2,341	96.86%	PSQI	≥8	23.30%	LM	5
40	Wang and Liu., 2013	Shanxi	N	NR	S,R	Yes	NR	21.5±1.1	49.80%	1,000	100.00%	PSQI	≥8.5	15.40%	LM	5
41	Wang et al., 2014b	Jiangsu	S	NR	C	Both	1-3	20.5±1.2	38.78%	1,131	98.38%	PSQI	≥8	29.50%	LM	5
42	Wu., 2014	Jiangsu	S	2012,6	C,S	NR	1-4	NR	47.59%	1,372	96.62%	PSQI	≥8	23.62%	LM	5
43	Wu et al., 2015a	Anhui	S	2013,10	C,M,R	NR	1-3	19.2±1.4	41.60%	4,747	98.84%	PSQI	≥8	9.80%	LM	6
44	Wu et al., 2015b	Zhejiang	S	2014,2-5	S	Yes	1-3	NR	0.00%	554	98.23%	PSQI	≥8	27.44%	LM	5
45	Xia et al., 2011b	Tianjin	N	2008,4-6	C,R,S	NR	1-3	21.12 ±1.57	50.11%	3,207	95.73%	PSQI	≥8	13.22%	LM	5
46	Xiao et al., 2000	Shanghai	S	NR	S	No	1-4	20.23±1.72	78.74%	621	95.54%	PSQI	≥8	18.04%	LM	5
47	Xu et al., 2016	Chongqing	S	2014,6	C,M,R	Both	1-4	20.2±1.2	27.03%	1,979	99.43%	PSQI	≥6	66.25%	LM	5

48	Yang et al., 2000	Shandong	N	NR	C,S	Yes	1-4	20.70±1.23	51.20%	584	97.01%	PSQI	≥8.5	15.75%	LM	5
49	Yang et al., 2010	Taiwan	-	NR	C	NR	1	18.5±0.9	72.11%	1,922	64.07%	PSQI	≥6	44.00%	LM	4
50	Yang et al., 2011	Hubei	S	NR	S,R	Both	1-3	NR	NR	887	98.56%	PSQI	≥7	30.10%	LM	5
51	Ye et al., 2016	Hubei	S	2012,5-6	C,R	NR	1-2	19.7±1.2	59.20%	2,422	95.56%	PSQI	≥6	42.60%	LM	5
52	Ye et al., 2013	Guangdong	S	NR	C	No	1-2	NR	100.00%	571	99.30%	PSQI	≥8	10.20%	LM	5
53	Yu and Ma., 2013	Anhui	S	2012,9-10	C,M,R	NR	1-2	19.23±1.13	50.50%	5,806	96.82%	PSQI	≥8	17.70%	LM	6
54	Yuan et al., 2015	Shanxi	N	NR	C	Yes	1-3	20.5±1.3	28.03%	4,548	88.81%	PSQI	≥8	19.80%	LM	5
55	Zhang et al., 2013	Shandong	N	2012	C,R	NR	NR	20.5±0.9	69.89%	837	98.47%	PSQI	≥8	16.96%	LM	5
56	Zhang et al., 2016	Xinjiang	N	NR	C,R,S	Yes	1-3	NR	28.53%	771	86.05%	PSQI	≥8	18.90%	LM	5
57	Zheng et al., 2016	Beijing	N	2014	C,R,S	Yes	2-5	20.1±1.3	46.30%	512	86.30%	PSQI	≥8	29.10%	LM	5
58	Zhou et al., 2007	Zhejiang	S	NR	C,R,S	Yes	1-2	19.39±0.84	22.94%	680	99.72%	PSQI	≥8	10.20%	LM	5
59	Zhu et al., 2016	Heilongjiang	N	NR	C,R,S	NR	NR	20.68±1.09	32.11%	928	94.69%	PSQI	≥8	32.11%	LM	5
60	Leng et al., 2015	Gansu	N	2014	C	Yes	NR	19-22	NR	987	98.70%	AIS	≥6	19.55%	LM	5
61	Wang et al., 2011	Guangxi	S	NR	R	NR	1-4	NR	48.15%	756	99.36%	AIS	≥6	17.90%	LM	5
62	Sun et al., 2000	Haerbin	N	NR	C,R	Both	NR	NR	48.32%	1,724	97.95%	CCMD-II	-	18.10%	LM	5
63	Chen et al., 2013	NR	NR	2012,6	S,R	Both	NR	18-22	NR	729	91.13%	Sleep dissatisfaction	-	37.04%	NR	4
64	Duan ., 2004	Sichuan	S	NR	R	No	NR	NR	NR	2,797	85.46%	Sleep dissatisfaction	-	18.65%	NR	4
65	Jin et al., 2014	Zhejiang	S	2012	C	Yes	1-3	19.7±1.03	21.02%	1,632	76.87%	Sleep dissatisfaction	-	22.70%	LM	4
66	Luo et al., 2012	Guangdong	S	NR	C,R	both	NR	NR	41.43%	1,038	92.68%	Sleep dissatisfaction	-	24.86%	CUS	4
67	Qian et al., 2015	Jiangsu	S	NR	C,S	NR	1-4	NR	33.27%	1,566	97.88%	Sleep dissatisfaction	-	53.40%	NR	4

68	Ren et al., 2013	Beijing	N	NR	C	NR	1	NR	26.65%	2,026	94.67%	Sleep dissatisfaction	-	7.65%	NR	4
69	Wang et al., 2015	Liaoning	N	NR	C,R	NR	1-4	NR	37.31%	1,442	96.01%	Sleep dissatisfaction		17.27%	NR	4
70	Wang and Yuan., 2007	Henan	N	NR	S,R	NR	NR	NR	NR	542	90.08%	Sleep dissatisfaction	-	38.40%	NR	4
71	Wang et al., 2003	Anhui	S	NR	C,R	BOTH	NR	NR	70.72%	2,500	92.59%	Sleep dissatisfaction	-	8.56%	NR	4
72	Xie et al., 2012	Beijing	N	2010,6-11	C,R	YES	NR	NR	37.96%	685	97.86%	Sleep dissatisfaction	-	9.40%	CUS	4
73	Ying and Lin., 2016	Guangdong	S	2012,9-11	C,S,R	YES	NR	19.5±2.4	46.67%	1,907	89.50%	Sleep dissatisfaction	-	1.90%	LY	5
74	Jin ., 2012	Jilin	N	NR	C,R	NR	1-4	17-25	43.60%	1,624	99.75%	Insomnia symptoms complaints	-	21.06%	LM	4
75	Lian et al., 2011	Guangdong	S	NR	C,R	NR	NR	18.23±0.83	38.96%	1,971	98.55%	Insomnia symptoms complaints	-	26.20%	NR	4
76	Wei et al., 2014	Shanxi	N	NR	R	YES	1-4	NR	34.42%	581	96.83%	SRSS	23	52.84%	LM	5

NR=Not Reported; SD= Standard deviation.

Sampling Method: Cluster sampling; M=Multistage sampling; R=Random sampling; S=Stratified sampling

AIS= Athens Insomnia Scale; CCMD-II= Chinese Classification of Mental Disorders version 2; PSQI= Pittsburgh Sleep Quality Assessment; SRSS= Self-rating Sleeping Scaling

CUS=Current symptom; LM=Last month; LY=Last year

Table 2. Subgroup analyses

Subgroups	Categories (Number of studies)	Proportion (%)	95% CI （%）	Events	Sample size	I^2 (%)	Q (p)
Assessment tool	Screening tool (62)	24.1	21.0-27.5	24,357	90,756	99.2	**12.8 (p=0.005)**
	Diagnostic tool (1)	18.1	16.4-20.0	312	1,724	0	
	Dissatisfaction with sleep quality (11)	20.3	13.0-30.3	4,114	16,864	99.4	
	Insomnia symptoms complaints (2)	23.6	18.9-29.0	858	3,595	92.2	
Time frame	Current symptoms (2)	15.7	5.6-36.7	322	1,723	98.3	**217.6 (p<0.001)**
	Last month (65)	23.9	21.0-27.2	25,381	95,736	99.2	
	Last year (1)	1.9	1.4-2.6	36	1,907	0	
Cut-off of PSQI	≥ 6(8)	47.2	35.6-59.1	8,722	19,654	99.6	**49.6 (p<0.001)**
	≥ 7(2)	26.3	19.5-34.4	380	1,390	89.2	
	≥ 8(47)	21.1	18.8-23.6	14,373	65,804	98.2	
	≥ 8.5(2)	15.5	13.8-17.4	246	1,584	0	
Sex	Female (38)	24.9	21.6-28.6	7,976	31,471	97.6	1.2 (p=0.25)
	Male (38)	22.0	18.6-25.8	6,140	25,739	97.3	
Survey year	2006-2010(7)	25.2	14.0-41.1	4,829	14,922	99.7	0.004 (p=0.94)
	2011-2015(26)	25.7	19.9-32.6	10,008	37,888	99.4	
Medical students	Yes (26)	25.5	21.9-29.6	8,616	31,605	96.1	**4.6 (p=0.031)**
	No (12)	19.0	15.1-23.7	1,697	8,596	98.2	
Grade	First (17)	25.3	19.2-32.5	7.201	22,519	97.4	0.63 (p=0.88)
	Second (16)	22.2	18.1-27.0	1,215	5,106	93.2	
	Third (16)	22.7	19.5-26.3	1,047	4,442	85.9	
	Fourth or Fifth (9)	22.8	18.0-28.5	564	2,310	88.8	

Sample size	500-1000 (31)	20.8	17.2-24.9	4,905	22,304	97.9	**4.3 (p=0.036)**
	>1000(28)	27.7	22.7-33.3	18,816	66,128	99.5	
Geographic	North (23)	21.2	17.8-25.2	7,968	34,314	98.5	0.8 (p=0.36)
locations	South (32)	23.9	19.8-28.5	11,951	46,687	99.1	
Rural /Urban	Rural (6)	22.9	17.6-29.2	961	4,096	94.6	0.04 (p=0.83)
	Urban (6)	22.1	18.4-26.4	771	3,305	86.1	

Bolded values: p<0.05; Q: Cochran's Q; PSQI: Pittsburgh Sleep Quality Index

Figure1: Flowchart of the selection of studies

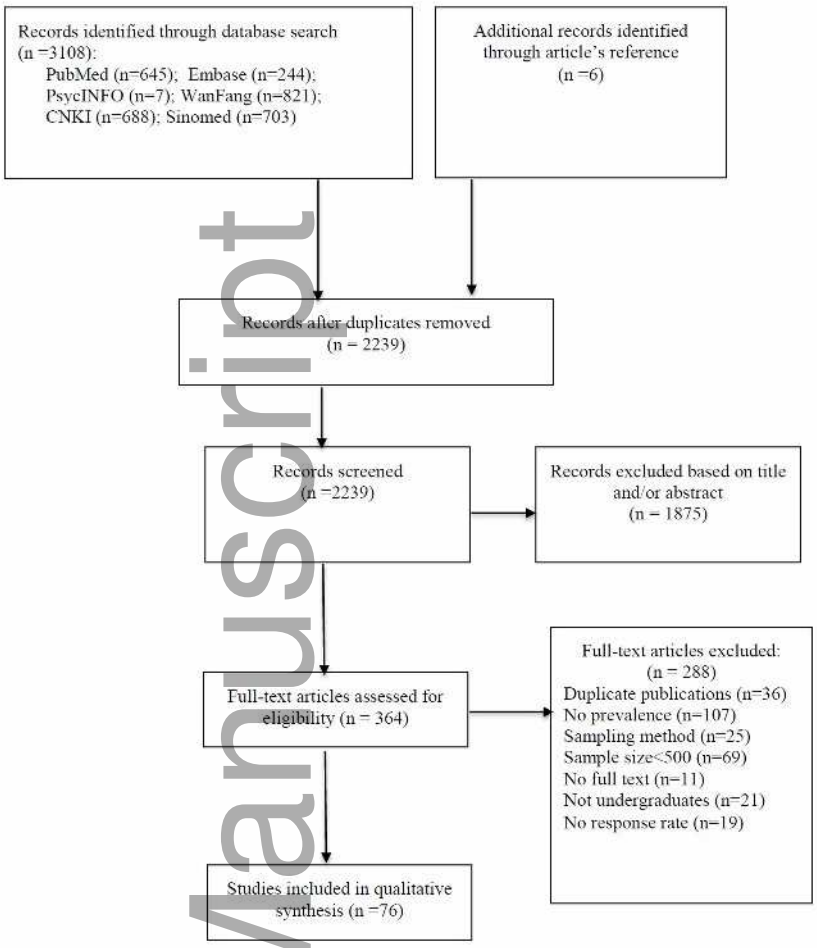

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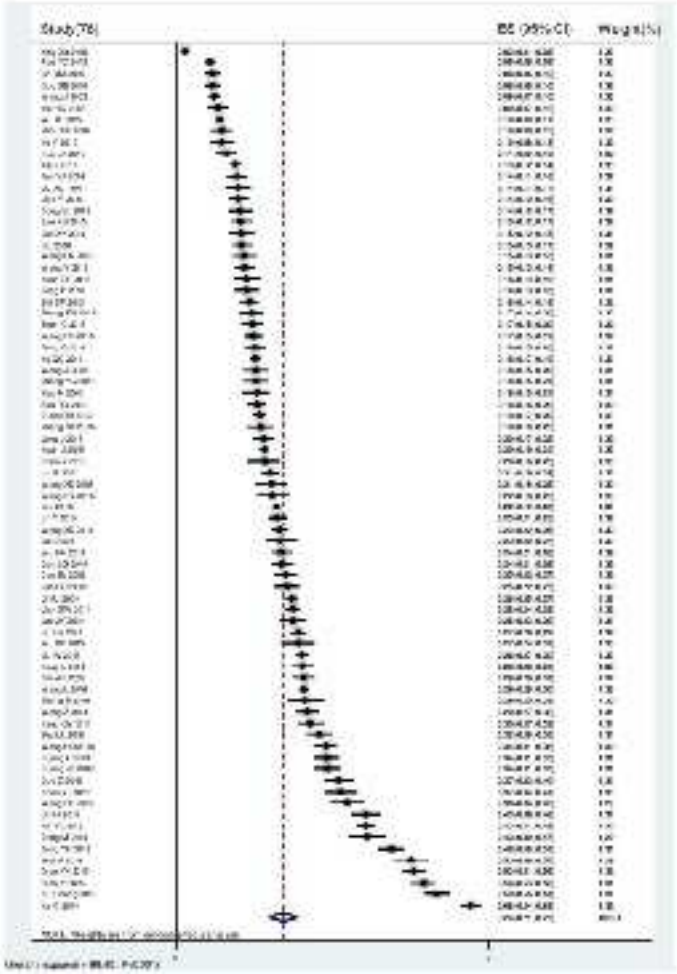
Figure 2: Forest plot of the prevalence of sleep disturbance with 76 studies in the university students



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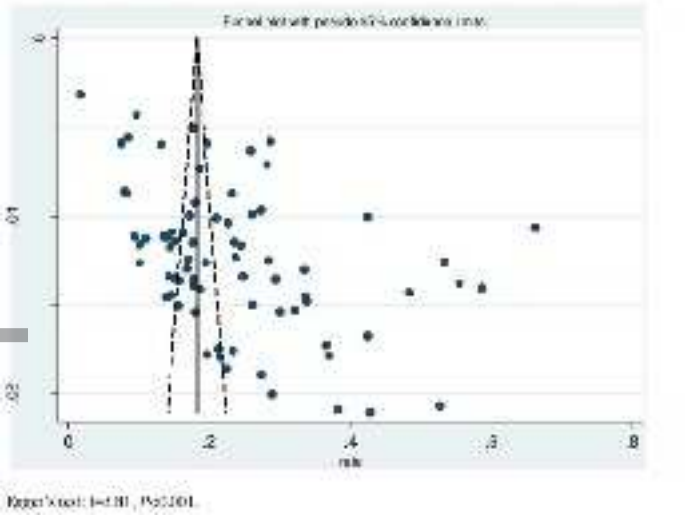

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