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Internet addiction and sleep problems: A systematic review and meta-analysis

Running title: Internet addiction and sleep problems

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Summary

The pathological use of the internet – conceptualized as 'internet addiction' – might be crucial in initiating and increasing sleep disturbances in the community. While inconsistent evidence is reported regarding the association of internet addiction and sleep disturbances, the severity of this association remains unclear. This systematic review and meta-analysis were conducted to increase our understanding of the relationship between internet addiction and sleep disturbances. A systematic review was conducted through Scopus, PubMed Central, ProQuest, ISI Web of Knowledge, and EMBASE using keywords related to internet addiction and sleep problems. Observational studies (cohort, case-control or cross-sectional studies) focusing on association between internet addiction and sleep disturbances including sleep problems and sleep duration were selected. A meta-analysis using random-effect model was conducted to calculate the odds ratio (OR) for experiencing sleep problems and standardized mean differences (SMDs) for sleep duration.

Eligible studies (N=23) included 35,684 participants. The overall pooled OR of having sleep problems if addicted to the internet was 2.20 (95% CI: 1.77–2.74). Additionally, the overall pooled SMDs for sleep duration for the IA group compared to normal internet users was -0.24 (95% CI: -0.38, -0.10).

Results of the meta-analysis revealed a significant OR for sleep problems and a significant reduced sleep duration among individuals addicted to the internet.

Keywords: internet addiction; problematic internet use; sleep problems; systematic review; meta-analysis

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Abbreviations

CI	Confidence interval
DSM	Diagnostic and statistical manual of mental disorders
IA	Internet addiction
MeSH	Medical Subject Headings
NIA	Non-addicted
OR	Odds ratio
PECO	Patient-Problem (P), Exposure (E), Comparison (C) and Outcome (O)
PIU	Problematic internet use
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SD	Standard deviation
SMD	Standardized mean differences
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology

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Introduction

Internet use has grown significantly in recent decades. According to statistics in 2018, there were around four billion internet users worldwide with North America having the highest percentage of the population using internet at 89.4% compared to other continents (1). Most studies indicate that the majority of internet users are teenagers and young people, although the level of internet use among adults is also increasing (2-5). Given the broad spectrum of internet users, there is a need to understand potential risks associated with internet use among the small minority of individuals that appear to display problematic or pathological internet use behavior (6).

Pathological or compulsive use of the internet (often conceptualized as 'internet addiction [IA]') has an inconsistent prevalence among different populations. Epidemiological studies have reported a significant variance in the prevalence of pathological internet use among adolescents and young people from 0.9 to 37.9% in Asia (7-10). In the United States, it ranges from 0.3% to 8.1% (11, 12), and in Europe it has been reported to be between 2% and 18.3% (13-15). However, many of these prevalence estimates are from convenience sampling. In a meta-analytic study, the prevalence of IA disorders among Chinese students was reported to be 11.3% (16). Another meta-analytic study by Zhang et al. reported the prevalence of IA among medical students to be 30.1% (17). Considering the number of internet users and the small but significant problem of internet addiction, the ongoing examination of the potential risks of pathological internet use is required (6).

Excessive use of the internet comprises problematic behavior in human interactions with information and communication technologies (18), and has become a major public health

problem (19). 'Internet addiction (disorder)', 'compulsive internet use', 'pathological internet use', and 'internet addictive behavior' have been used to describe the symptoms of extreme problematic internet use and the associated social problems that internet users have (20). Empirical research charting the development from adaptive internet use to pathological behavior is ongoing (21), but these two groups have distinct characteristics. For adaptive users, the internet acts as a supportive tool rather than a coping strategy. They use the online accessibility of internet connections to facilitate current and new communication, enhance socialization and self-esteem, and reduce loneliness (22-24). In contrast, users with pathological behaviors spend more hours on online activities such as compulsive gambling, excessive pornography consumption, compulsive shopping, and excessive gaming (24-27).

Kaplan states that IA is the category of behavioral addictions that include the components of tolerance, loss of control, retreat, escape, lying and deception, neglect of physical and psychological consequences, and disturbances in home and educational affairs (28). Serious psychological and emotional problems may develop for pathological internet users (6). Potential associations between pathological internet use and impulsivity (29), depression (30), anxiety (31), psychosis (32), obsessive-compulsive symptoms (33), and social anxiety (34) have been reported.

In a systematic review, Carli et al. (6) reported the association between pathological internet use and related psychopathology. It was found that depression had the most significant correlation with pathological internet use. One of the potentially significant causes of depression associated with pathological internet use can be sleep disorders associated with excessive internet use. The

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results of various studies have indicated a relationship between pathological internet use and sleep disturbances such as excessive online behavior reducing sleeping time (24, 35), tendency to sleep late (36), sleep disorders (37), insomnia (38), increased fatigue (39), and drowsiness during the day (40). In addition, exposure to bright light has been associated with the suppression of melatonin secretion and delayed sleep and wakefulness, which can increase consciousness and sleep disturbances (41, 42).

The excessive use of social media and internet plays an important role in initiating and increasing sleep disturbances within the younger community (43). De Vries et al. found that internet users with psychiatric disorders are more likely to experience sleep problems, depression, anxiety, and autism (20). Several studies have considered the quality of sleep in people with IA (12, 18, 44-46), but in some studies no significant relationship has been found (19). In studies that have reported a significant relationship between IA and sleep disturbances, the severity of such a relationship has been varied. For example, Kiatzawa et al. reported that university students with problematic internet use reported 52% higher chance of sleeping disturbances than those with ordinary internet use (45), while Li et al. reported that the chance of having sleep problems in students with IA was three times higher than in normal internet users (47). A systematic review in 2014 reported an association between online gaming addiction, problematic internet use (PIU), and sleep problems. The results of the study showed that pathological internet use appeared to be associated with a low sleep quality and subjective insomnia (18). Although this study provided valuable information concerning the relationship between internet use and sleep disturbances, a quantitative meta-analysis of findings was never conducted on this relationship and the severity of the association remains unclear.

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Considering the importance of IA and its potentially increasing prevalence, further studies are needed to examine related factors and negative consequences. Despite the increasing number of studies on this field, there has been no recent review examining the relationship between IA and sleep disturbances. Therefore, to summarize available findings and collate more solid evidence for a deeper understanding of the relationship between IA and sleep disturbances, the present systematic review and meta-analysis was conducted.

Methods

In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for designing and implementing systematic review studies (48), the following steps were taken: a systematic literature search, organization of documents for the review, abstracting and quality assessment of each empirical study, synthesizing data, and writing the report. The protocol was registered in the PROSPERO prospective register of systematic reviews (ID = CRD42018108669) (49). As this was a systematic review with meta-analysis, approval from an ethics committee was not required.

Search strategy

The systematic literature search was conducted on databases including Scopus, PubMed Central, Science Direct, ProQuest, ISI Web of Knowledge, and EMBASE. The search terms were extracted from published reviews and primary studies. They were also identified by means of PubMed Medical Subject Headings (MeSH) and EMBASE Subject Headings (EMTREE). According to the PECO framework for formulating clinical questions, queries comprise four

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aspects: Patient-Problem (P), Exposure (E), Comparison (C) and Outcome (O) (50). In this regard, IA as exposure and sleep disturbances as outcome were two components in formulating the search strategy. The Boolean search method was used and keywords were connected together with AND, OR and NOT Internet addiction and sleep disturbances and their suggested entry terms were main keywords in the search strategy. Search syntax was adapted to use in different databases. The search strategy is provided as Supplementary File 1. Additionally, further sources including reference lists of included studies and previous systematic reviews on the study topic as well as two key journals (i.e., *Journal of Behavioral Addictions* and *Sleep Medicine Reviews*) were searched to increase the likelihood of retrieving relevant empirical studies.

Inclusion criteria

Type of studies: Observational studies including cohort, case-control, and cross-sectional studies were included if the relationship between IA and sleep disturbances were reported as an outcome. Also, studies met the inclusion criteria if they were published in peer-reviewed papers in English between January 1990 and August 2018. Other types of studies including systematic reviews, letter to editor, case report, case series, and clinical trials were excluded.

Type of participants: Participants from all age ranges who had been assessed for IA (and its equivalents) of any form reported by valid and reliable measures were included. No limitation was exerted upon age, gender, or educational status.

Type of exposure: IA was chosen as the exposure measure. In the present systematic review, IA was considered as being adequately assessed if it used psychometrically valid screening instruments and/or comprised DSM5 characteristics of Internet Gaming Disorder.

Type of outcomes measure: Two main outcome measures (experience of sleep problems and sleep duration) were selected as sleep-related disturbances in the present systematic review. In relation to sleep disturbances, studies were considered eligible if they adequately reported the presence of sleep problems based on the reported diagnosis or the assessment measure. Regarding sleep duration, studies were considered eligible if they had reported sleep duration in mean hours with standard deviation (SD). The present systematic review and meta-analysis evaluated the effect of sleep problems and sleep duration and its association with IA rather than any specific sleep disorder (e.g., hypersomnia, narcolepsy, and insomnia) because the overwhelming majority of studies assessed sleep symptomatology rather sleep disorder diagnoses.

Study selection

The title and abstract of all papers retrieved during the electronic and manual follow-up search process were examined based on the inclusion criteria. The full texts of relevant papers were examined based on the aforementioned criteria.

Quality assessment

The modified STROBE checklist was used to assess the quality of the selected observational studies with cohort, case-control, and cross-sectional design. The STROBE is a valid instrument that proposes 22 items for reporting or evaluating different sections of observational studies (51). For the purpose of quality assessment in the present review, the modified STROBE checklist with 14 items was prepared and used. The complete checklist is provided in Supplementary File 2. For quality assessment, a score of ‘0’ was assigned to an item if that item did not meet its item

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explanation; a score of '1' was assigned to an item if that item met its item explanation. The highest quality score that could be attained by each study was 14.

Data extraction

After screening and examining the quality of selected studies, data were extracted and recorded in pre-designed forms including data about the name of the first author, year, study design, country of the study, data collection method, number of participants, gender, age, assessment of internet addiction, assessment of sleep problems, numerical results regarding the relationship between IA with sleep problems and sleep duration.

To assess association between IA and sleep problems, data of 2*2 tables calculating odds ratios (ORs) of sleep problems regarding IA status were extracted (where possible) from primary studies. If these data were not provided, crude and adjusted ORs with information concerning the confidence interval (CI), mean, and SD of sleep scores for both groups of normal and internet addicted participants were extracted. Additionally, some studies reported Pearson correlation coefficients between these variables, which were also extracted.

To assess association between IA and sleep duration, means and SDs of sleep duration besides the number of participants for both groups of normal and internet addicted participants were extracted. Two studies reported data in three categories of normal internet user, possibly internet-addicted, and internet-addicted (52, 53). In these cases, data related to means, SDs, and sample size of normal users and internet-addicted individuals were extracted.

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In cases that relevant studies did not report extractable data regarding the association between IA and sleep problems (e.g., studies in which IA was examined as moderator variable) or sleep duration, the corresponding author was contacted via email to request the minimum required data for meta-analysis. E-mails were sent twice with approximately seven days' interval. It should be noted that study selection, quality assessment, and data extraction were processes performed independently by two reviewers. In whole processes, disagreements were resolved through discussion. The Cohen's Kappa coefficient was calculated to determine the level of agreement between the two reviewers.

Data synthesis

A quantitative synthesis using the PRISMA guidelines via the STATA software version 13 was conducted. As two outcome measures (sleep problems and sleep duration) were selected for the present review, two main and separated meta-analyses were conducted (i.e., IA and sleep problems, and IA and sleep duration).

IA and sleep problems: Data concerning the relationship between IA and sleep problems were reported in three forms. Sixteen studies provided extractable data of 2*2 tables to calculate ORs of sleep problems regarding IA status. Three studies reported mean and SD of scores related to sleep problems based on IA status, and four studies reported Pearson correlation coefficients regarding the association between sleep problems and internet addiction. Consequently, the authors conducted a meta-analysis for the group of studies with the same outcome which had enough studies to do so. While the findings of all retrieved studies via the systematic review

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process are reported, meta-analysis was conducted for the subgroups of studies with reported data for calculating ORs (16 studies).

***IA and sleep duration**:* Data concerning the relation of IA and sleep duration were reported as mean and SD among two groups of IA and normal. In this regard standardized mean differences (SMDs) and their 95% CIs were calculated for analysis.

Since studies were taken from populations with various effect sizes, the random effect model was used, which calculates study weights from both in-study and between-study variances, considering the extent of variation or heterogeneity (54). Effect sizes are expressed as ORs and their 95% CIs were calculated for analysis. Heterogeneity was assessed statistically using the standard χ^2. The random-effect model is more appropriate when heterogeneity is present. For each model, the between-study heterogeneity was estimated using the Q Cochrane statistic. Also, the severity of heterogeneity was estimated using the I^2 index. $I^2<25\%$ is considered as mild heterogeneity, $25\%<I^2<50\%$ is considered a moderate heterogeneity, and $50\%<I^2<75\%$ is considered severe heterogeneity (55). In case of severe heterogeneity, subgroup analysis or meta-regression was used based on number of studies in each group. If the number of studies in any group was less than four studies, a meta-regression was used. For evaluating quality analysis and investigating the effect of quality of primary studies on the final results, the effect of study quality scores on key measures was assessed through meta-regression. Publication bias or reporting bias was assessed using the funnel plot alongside the Begg's Test and Eggers' Test. Sensitivity analysis was examined by the Jackknife Method. In this method, which is also known

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as the ‘one out method’, quality and consistency of the results were evaluated by removing each study individually.

Results

The search process led to the retrieval of 508 potentially relevant papers. Screening based on the title and abstract revealed 165 papers potentially eligible for further review. During this process, 54 papers were excluded due to duplication and five papers were published in languages other than English. The full-texts of 106 remaining papers were reviewed and 22 papers were selected based on the inclusion criteria outlined above. The reference list of the included studies was read to find potentially related studies, and one further paper was included following this process. Overall 23 papers (22 from electronic search and one from the manual search) were found to be eligible for further analysis. A search carried out in the two key journals did not provide any more papers to be included for review. Cohen's kappa coefficient between the two reviewers was 0.88 during the abstract review (95% confidence interval [CI] 0.76–0.99) and 0.90 in the full-text stage (95% CI, 0.74–1.0).

Figure 1 shows the search process according to the PRISMA flowchart.

Study description

A majority of the 23 studies (n=22) had cross-sectional designs, and one of them was a longitudinal study (44). It should be noted that in data extraction process, the baseline data of the longitudinal study were extracted. This was done to have data comparable to other included studies. Consequently, the design of this study was analyzed as a cross-sectional study. A total of 35,684 individuals participated in these studies. The largest sample size was 6,510 individuals in

the study by Byung-Soo Kim from South Korea (56). A study of Herlache (2018) in the USA had the lowest sample size (n=143) (57). The studies were performed in 14 different areas of the world, including South Korea (n=4), Turkey (n=3), mainland China (n=2), Japan (n=2), Taiwan (n=2), Spain (n=2), Hong Kong (n=1), Vietnam (n=1), Nepal (n=1), Lebanon (n=1), Iran (n=1), Switzerland (n=1), the USA (n=1), and Israel (n=1). Young's Internet Addiction Test (IAT) was the most frequently used measure to assess IA status among participants (n=17), and the Pittsburg Sleep Quality Index (PSQI) was the most frequently used measure to assess sleep problems (n=9). Table 1 provides a summary regarding detailed characteristics of included studies.

Quality assessment

Evaluation of the selected studies using the modified checklist of the STROBE with 14 items is presented in Table 1. All studies clearly defined the objectives, variables, and measurements using well-established criteria. The majority of the studies had issues concerning reporting bias, how the sample size was calculated, how the missing data were addressed, analytical methods regarding sampling strategies, and sensitivity analysis. The quality assessment scores and Figure 2 show the graphical representation of the quality of studies.

Outcome measures

Findings in outcome measures are reported in two separate sections (below) regarding sleep problems and sleep duration.

IA and sleep problems

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Overall OR estimation: All the included studies showed significant relationships between IA and sleep problems. Three studies examined the mean difference of total sleep scores between IA and non-IA (NIA) groups and found significant differences (47, 58, 61). Four studies examined the associations using Pearson's correlation coefficient. Significant correlations of 0.25 to 0.90 were reported in these studies (46, 57, 62, 63). Meta-analysis of the remaining 16 studies was done to calculate the OR of having sleep problems if individuals had IA. It should be noted that due to difference in reporting outcome measures between included studies (three reported mean differences, four reported correlation coefficients, and 16 reported data to estimate OR), final quantitative synthesis regarding IA associations and sleep problems was conducted for the subgroup of 16 studies which had crude data (or through emailing the corresponding author of the original studies) to estimate the overall OR. Figure 3 shows the forest plot regarding the OR of sleep problems for the IA group. The overall pooled OR was 2.20 (95% CI: 1.77–2.74).

Meta-regression: Meta-regression analysis demonstrated that many variables had no significant effect on the association between IA and sleep problems (Table 2), including geographical region by continent (i.e., Asia, Europe, and America) (p=.24), data collection method (p=.99), number of participants (p=.27), mean age of participants (p=.99), measure for assessing internet addiction (p=.73), quality of the study (p=.33), and belonging to specific types of participant group (i.e., being a student, university student, community representative, or psychiatric patients) (p=.51). Only the measure for assessing sleep problems (p=.014) had significant effect on the association between IA and sleep problems. Since the measure for assessing sleep problems had a significant effect, further subgroup analysis was performed considering these measures as standardized or self-designed measures (i.e., whether the sleep questionnaire was designed by the authors). Subgroup analysis showed that self-designed sleep measures appeared to alter this

association because the overall estimated OR for subgroup with standardized measure for sleep problems was 2.40 (95% CI: 1.74- 3.33) while the overall estimated OR for subgroup with self-devised measure was 1.96 (95% CI: 1.45-2.65).

IA and sleep duration

Overall SMD estimation: Meta-analysis of included studies was done to calculate the SMD. Figure 4 shows the forest plot of SMDs for sleep duration for IA group compared to normal internet users, and the overall pooled SMD was - 0.24 (95% CI: -0.38, -0.10) hours.

Meta-regression: Meta-regression analysis demonstrated that many variables had no significant effect on the association between IA and sleep duration (Table 2) including data collection method (p=.179), number of participants (p=.843), mean age of participants (p=.568), groups of participants (p=.112), and quality of the studies (p=.399). The measure for assessing IA (p=.06) was the only variable that had a significant effect.

Publication bias: For association between IA and sleep problems, the visual funnel plots, the Egger's Test (t = 0.65, p<.0.524) and the Begg's Test (z = 0.59, p<.558) demonstrated that there was no publication bias. For the association between IA and sleep duration the visual funnel plots, the Egger's Test (t = -1.07, p=.317) demonstrated that there was no publication bias (Figure 5).

Sensitivity analysis

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Sensitivity analysis was performed using the Jackknife method. After excluding each study sequentially, the recalculated pooled results did not change significantly indicating that there was no outlying study that influenced the overall results significantly (Table 3).

Discussion

Despite the increasing amount of research that has examined the relationship between IA and sleep (including sleep problems and sleep duration), to the best of our knowledge, no systematic review or meta-analysis has been conducted to summarize the findings. More specifically, the first study assessing IA and sleep was published in 2007 (67). Consequently, the evidence of the association between IA and sleep has been studied for 12 years, and the cumulative evidence requires summarizing. The present review is the first meta-analysis that uses the empirical evidence from the past 12 years to understand the association between IA and sleep problems using OR and SMD. After a rigorous selection method using PRISMA guidelines, 23 studies (22 using a cross-sectional design and one using a longitudinal design) with 35,684 participants were included in the present meta-analysis. The results indicated that the IA group as compared with NIA group had significantly increased chances of suffering from sleep problems (overall pooled OR=2.20) and had a decreased sleep duration (overall pooled SMD=-0.24 hours).

Almost all the analyzed studies had an adequate number of participants in sample size with the smallest sample being 143 in a US study (57) and the largest sample being 6,510 in a South Korean study (56). Additionally, these studies were conducted across 14 countries with most of them being in Asia (n=19), followed by Europe (n=3) and the USA (n=1). Although the results of the meta-analysis in this present review were primarily derived from Asian populations, the

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sensitivity analysis revealed that the association between IA and sleep problems was consistent across all studies. In other words, the small proportion of the European and North American data in this review had consistent results with the Asian data. Hence, the consistency across the studies strengthens our findings, emphasizing the association between IA and sleep. The consistency could be attributed to the commonly used IA and sleep instruments: 17 studies used the IAT to assess IA (19, 20, 43, 45, 47, 52, 53, 56, 58-65, 68) and nine used the PSQI to assess sleep problems (38, 45-47, 57, 60, 62, 63, 66). Furthermore, the high quality of these studies (all studies have clearly defined their objectives, variables, and measurement using well-established criteria) and the comparable participants in these studies (19 studies on high school or university students [19, 38, 43-47, 52, 53, 57, 58, 60-62, 64-68]) ensure the homogeneity among the studies and result in consistent findings. However, it should be noted that the majority of the studies had some methodological concerns, including (i) the lack of reporting bias and conducting sensitivity analysis, (ii) insufficient information in sample size calculation and missing data management, and (iii) unreported information in some analytical methods (e.g., sampling strategies). Nevertheless, given the consistent findings in the present meta-analysis, the methodological concerns might have minimal impacts on the present findings.

The main finding was that all the 23 studies showed significant relationships between IA and sleep problems with a relatively high pooled OR: IA individuals had 2.2 times more chances of having sleep problems than NIA people. Meta-regression analysis further revealed that the association between IA and sleep problems could be affected by the instruments used to assess sleep problems. More specifically, subgroup analysis showed that self-designed sleep measures appeared to lower the association between IA and sleep problems: pooled OR=2.40 for studies

using standardized measures on sleep problems (20, 38, 43-47, 52, 57, 58, 60-63, 66-68); =1.96 for studies using self-designed measures (19, 53, 56, 59, 64, 65). Given that standardized measures usually have stable and robust psychometric properties, the pooled OR from studies using standardized measures may be more accurate than those using self-designed measures in the association between IA and sleep problems. More specifically, the self-designed measures may have had more measurement errors than the standardized measures. For example, only nine studies used a validated questionnaire to assess sleep problems (i.e., PSQI). In contrast, other studies used self-designed sleep questionnaires or non-sleep-specific measures (e.g., general health questionnaire). Therefore, the findings from these latter studies may not have capture adequately the extent of sleep problems. Consequently, the associations between IA and sleep problems in the studies using self-designed or non-sleep-specific measures are questionable and, in some cases, may be less valid.

In terms of sleep duration, the meta-analysis results found that the IA group slept 0.24 hours (~14.4 minutes) less than did NIA group. Although a 15-minute reduction in sleep duration for individuals with IA does not appear to be clinically relevant, this finding should be simultaneously taken into account with the sleep problems among individuals with IA. That is, individuals with IA slept less (though not substantially) and had a worse sleep quality than those without IA. Therefore, a 15-minute decrease in sleep duration pooled with a poor sleep quality may contribute to an increase in deleterious effects on health and/or daytime functioning for individuals with IA. In other words, individuals with IA may not have effective rest from their sleep (due to the shortage of sleep and the poor sleep quality), and subsequently develop health problems, such as emotional distress and fatigue. Indeed, one study showed that for night-shift

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nurses, two 15-minute naps with good quality may effectively reduce tension (69), which supports the notion that even 15 minutes of restful sleep contributes to good health. However, the results of the present meta-analysis cannot infer a causality between sleep and health because all but one study adopted a cross-sectional design (19, 20, 38, 43, 45-47, 52, 53, 56-68). Although some studies have suggested that the presence of sleep problems may cause an overuse of the internet (44, 70, 71), future research utilizing randomized controlled trials or longitudinal designs are required to support the suggestion.

The strengths of the present meta-analysis include the comprehensive search in the literature and rigorous methodology. More specifically, the literature was searched for using major databases with clearly identified keywords according to PECO framework. The methodology includes the quality assurance, meta-regression, and sensitivity testing. Therefore, the findings in this present meta-analysis should be robust. However, there are some limitations in this meta-analysis. First, as mentioned earlier, 22 of 23 analyzed studies were cross-sectional studies, which cannot provide evidence in causality. Second, the majority of the participants were students and Asians, which restrict the present review's generalizability. Third, all the analyzed studies used self-reports in assessing IA or sleep. Therefore, well-known biases such as social desirability and memory recall bias cannot be excluded. Finally, this review cannot draw definitive conclusions concerning the effect of Internet addiction on circadian rhythm and the stability of sleep-wake schedules due to the lack of empirical evidence. Through the literature search, we only found one relevant study (58), which showed that the effects of Internet use problems on sleep-wake behavior problems did not change with increasing Internet use problems. Therefore, future

systematic reviews and meta-analysis will need to further explore this important topic when the literature accumulates sufficient evidence.

Conclusion

The internet has increasingly become part of the daily life (both work and leisure) for hundreds of millions of individuals across the world. Considered as a tool or a source of information or entertainment for most of the people, internet use can also trigger a compulsive need in a minority of individuals. It is important to note that Internet Addiction Disorder is not yet a recognized diagnosis and that the addiction can be restricted to one application or behavior such as cybersex, gambling, gaming, social networking, etc. Research in that area is still in its infancy. As seen in this review, most of the studies devoted to IA and sleep disturbances are restricted to young people. However, the results that are published to date are arguably alarming so that further study is needed on this modern phenomenon. Needless to say, the individuals most susceptible to IA appear to be children, teenagers, and young adults, a highly vulnerable segment of the population because most of them are still in their developing years. Clinically, this demonstrates that there is a very negative effect on sleep if adolescents and young adults with IA fail to engage in good sleep hygiene practice. Therefore, assisting young people in developing good sleep hygiene (e.g., not using the internet or their smartphone before bedtime or while in bed) should be relevant in clinical practice. The results of the present review show that there is a clear association between internet addiction (and its equivalents), sleep problems, and curtailed sleep duration. There is a need for further research to examine the directionality of this association and to study if specific types of internet addiction cause greater impact on sleep than others.

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Practice Points

1. Internet addiction may result in sleep problems, including lowered sleep quality and reduced sleep duration.

2. Current evidence demonstrates that the association between internet addiction and sleep disturbances exists across different countries, cultures, and ethnicities.

3. Using robust standardized psychometric measures (rather than self-designed measures) in assessing internet addiction and sleep quality is recommended. Standardized measures can ensure the validity and stability in assessing internet addiction and sleep.

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Research Agenda

1. Using longitudinal designs and/or randomized controlled trials to assess the causality between internet addiction and sleep can provide healthcare providers direction in treating people with internet addiction problems or those with sleep problems.

2. Most of the studies included in the present meta-analysis comprised students and Asians. Therefore, studies on large samples of Caucasians and those in other age groups are needed to examine whether the association between internet addiction and sleep is consistent across ethnicities and age groups.

3. Studies on reducing or preventing internet addiction are needed to investigate whether the reduced internet addiction can help improve sleep.

4. Impacts of different types of internet addiction are needed to understand which types of internet addiction contribute most to the sleep problems.

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Table 1- **Summarized characteristics of selected primary studies**

First Author, year	Country	Data collection method	Sample size	Age (Mean ± SD or age range)	Group of participants	STROBE score	IA measure	Sleep measure
Park, 2018 (58)	South Korea	Paper-based	766	15.05 ± 1.35	School students	9	Young's Internet Addiction Scale	ISI & ESS
Kitazawa, 2018 (45)	Japan	Paper-based	1258	19.34 ± 1.95	University students	9	Young's Internet Addiction Scale	PSQI
Herlache, 2018 (57)	USA	Online	143	19.85 ± 2.45	University students	6	Problematic Internet Use scale	PSQI
Li, 2017 (47)	China	Paper-based	1015	7th to 9th grade	School students	10	Young's 8-item Diagnostic Questionnaire	PSQI
Zhang, 2017 (19)	Vietnam	Online	566	15 to 25 years	Universities as well as high schools Students	8	Short form Internet Addiction Test (s-IAT)	Self-devised
Kim, 2017 (59)	South Korea	Face-to-face interview	3212	30.92 ± 9.35	Community population	11	Korean version of Young's Internet Addiction Test	Self-devised
Bhandari, 2017 (60)	Nepal	Paper-based	937	21.01 ± 2.18	University students	12	Young's Internet addiction Scale	PSQI
Younes, 2016 (61)	Lebanon	Paper-based	600	20.36 ± 1.84	University students	9	Young's Internet addiction Scale	ISI
Chen, 2016 (44)	Taiwan	Paper-based	1054	13.60 ± 0.3	School students	10	Chen Internet Addiction Scale	Sleep Habit Questionnaire
Tan, 2016 (46)	China	Paper-based	1661	14.53	School students	9	Chen Internet Addiction Scale	PSQI
Kootesh, 2016 (62)	Iran	Paper-based	250	Not reported	University students	4.00	Young's Internet Addiction Scale	PSQI
Reed, 2015 (63)	Spain	Online	550	29.73 ± 13.65	Community population	9	Young's Internet Addiction Scale	PSQI
Surís, 2014 (64)	Switzerland	Paper-based	3067	14.31 ± 0.03	School students	9	Young's Internet Addiction Scale	Self-devised
Ekinci, 2014 (65)	Turkey	Paper-based	1212	16.00 ± 0.98	School students	8	Young's Internet Addiction Scale	Self-devised

First Author, year	Country	Data collection method	Sample size	Age (Mean ± SD or age range)	Group of participants	STROBE score	IA measure	Sleep measure
Cheng, 2012 (66)	Taiwan	Paper-based	4318	Not reported	University students	7	Chen IAS	PSQI
Cheung, 2011 (38)	Hong Kong	Paper-based	719	14.70 ± 2.02	School students	7	Chen IAS	PSQI
Choi, 2009 (52)	South Korea	Paper-based	2336	16.70 ± 1.00	School students	7	Young's Internet Addiction Scale	ESS
Jenaro, 2007 (67)	Spain	Online	333	21.60 ± 2.45	University students	9	Internet Over-use Scale (IOS);	GHQ
De Vries, 2018 (20)	Japan	Online	231	42.20	Psychiatric patients	8	Young's Internet Addiction Scale	AIS-8
Sami, 2018 (43)	Israel	Paper based	631	14.95 ±1.53	School students	6	Young's Internet Addiction Scale	Child and Adolescent Sleep Checklist
Kim, 2016 (56)	South Korea	Face to face interview	6510	18-64 years	Community population	9	Korean version of Young's Internet Addiction Test	Self-devised
Canan, 2013 (53)	Turkey	Paper-based	1965	16.04 ± 1.20	School students	8	Young's Internet addiction Scale	Self-devised
Bener, 2018 (68)	Turkey	Paper-based	2350	20.95 ± 1.36	University students	11	Young's Internet addiction Scale	ESS

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Table 2- meta-regression analysis

	Sleep problem					Sleep duration				
Variable	β	p	I^2 residual (%)	Adj.R^2 (%)	tau^2	β	p	I^2 residual (%)	Adj.R^2 (%)	tau^2
Continent	1.19	0.24	97.91	3.21	1.59	-	-	-	-	-
Data collection method	-0.002	0.99	98.27	- 7.1	1.76	-0.112	0.18	83.15	13.7	0.38
Number of participants	-0.0002	0.27	98.18	2.24	1.61	0.00002	0.84	86.02	-14.28	0.05
Mean age of participants	-0.001	0.99	98.68	-10.00	2.25	-0.014	0.57	79.88	41.58	0.03
Participants groups	-0.23	0.51	98.23	-3.77	1.70	0.235	0.11	82.89	22.37	0.03
Measure of Internet Addiction	-0.052	0.73	98.26	-6.21	1.74	0.065	0.06	81.48	31.19	0.03
Measure of sleep problem	0.421	0.01	97.16	32.49	1.11	-	-	-	-	-
Quality of studies	-0.201	0.32	98.28	0.20	1.64	0.047	0.40	86.22	-4.47	0.05

Note. Ten studies were included in meta-analysis of sleep duration regarding IA, as all of them were from Asian countries; no further meta regression was conducted regarding continent. Also as the outcome measure for this group was sleep duration, so no further analysis regarding sleep measure was conducted in this group.

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Table 3- results of sensitivity analysis

Sleep problem		Sleep duration	
excluded study	Pooled OR	excluded study	Pooled SMD
Li, 2017 (47)	2.14	Park, 2018 (58)	-0.22
Zhang, 2017 (19)	2.24	Kitazawa, 2018 (45)	-0.26
Kim, 2017 (59)	2.23	Bener, 2018 (68)	-0.23
Bhandari, 2017 (60)	2.15	Li, 2017 (47)	-0.23
Chen, 2016 (44)	2.30	Zhang, 2017 (19)	-0.26
Surís, 2014 (64)	2.12	Kim, 2017 (59)	-0.28
Ekinci, 2014 (65)	2.25	Chen, 2016 (44)	-0.24
Cheng, 2012 (66)	2.21	Canan, 2013 (53)	-0.20
Cheung, 2011 (38)	2.16	Cheung, 2011(38)	-0.26
Choi, 2009 (52)	2.27	Choi, 2009 (52)	-0.21
Jenaro, 2007 (67)	2.16		
De Vries, 2018 (20)	2.19		
Sami, 2018 (43)	2.05		
Kim, 2016 (56)	2.27		
Canan, 2013 (53)	2.29		
Bener, 2018 (68)	2.31		
Pooled OR (with all studies)	2.20	Pooled SMD (with all studies)	-0.24

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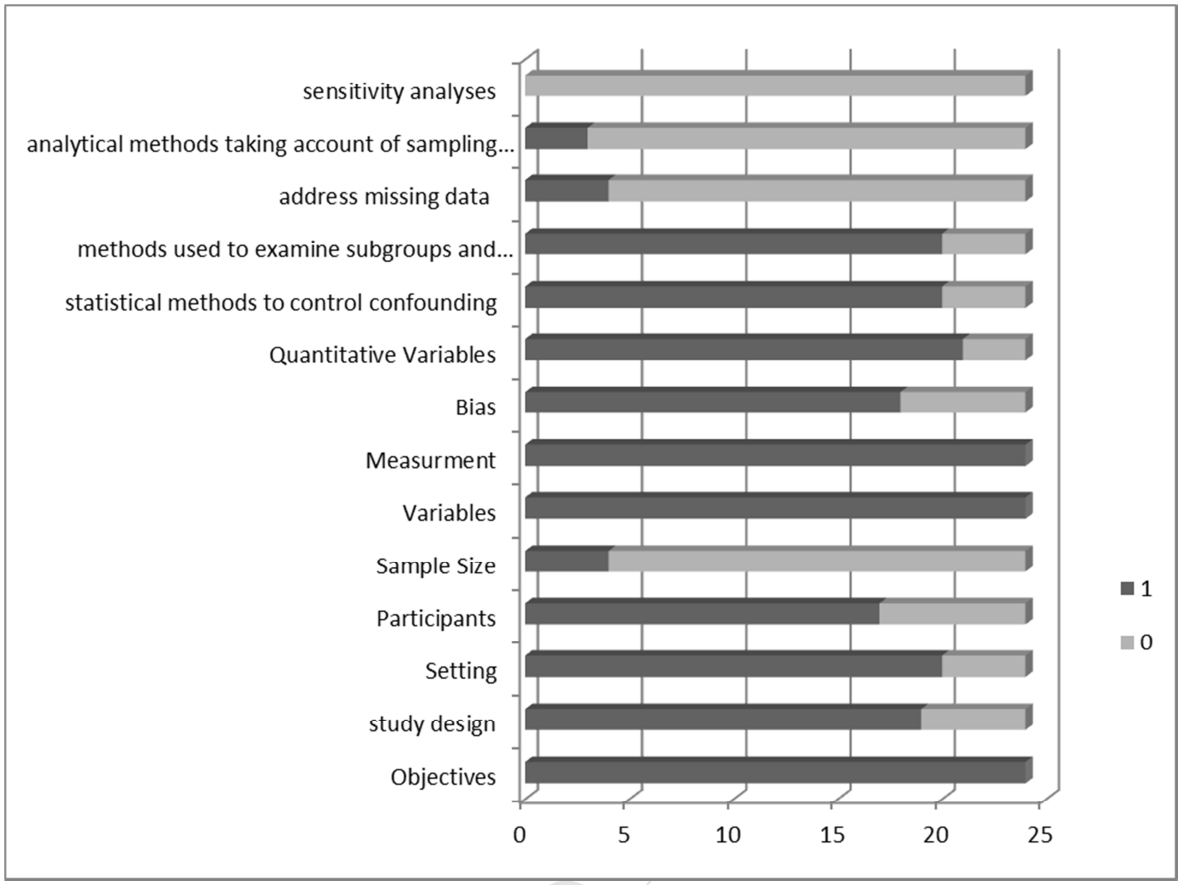

Figure 2- Graphical representation of the quality assessment of included studies based on checklist items

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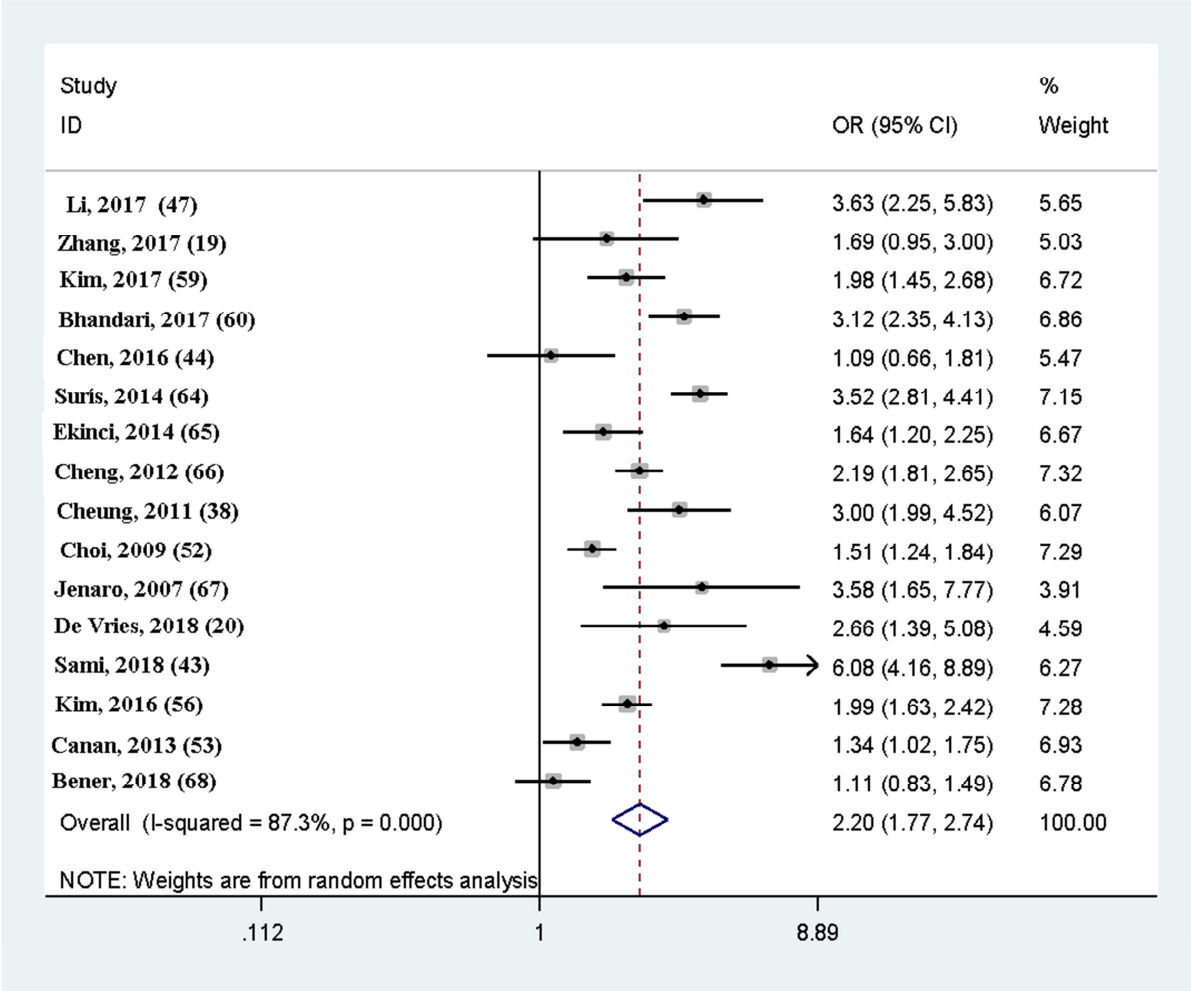

Figure3. Forest plot of overall ORs for sleep problem among IA users

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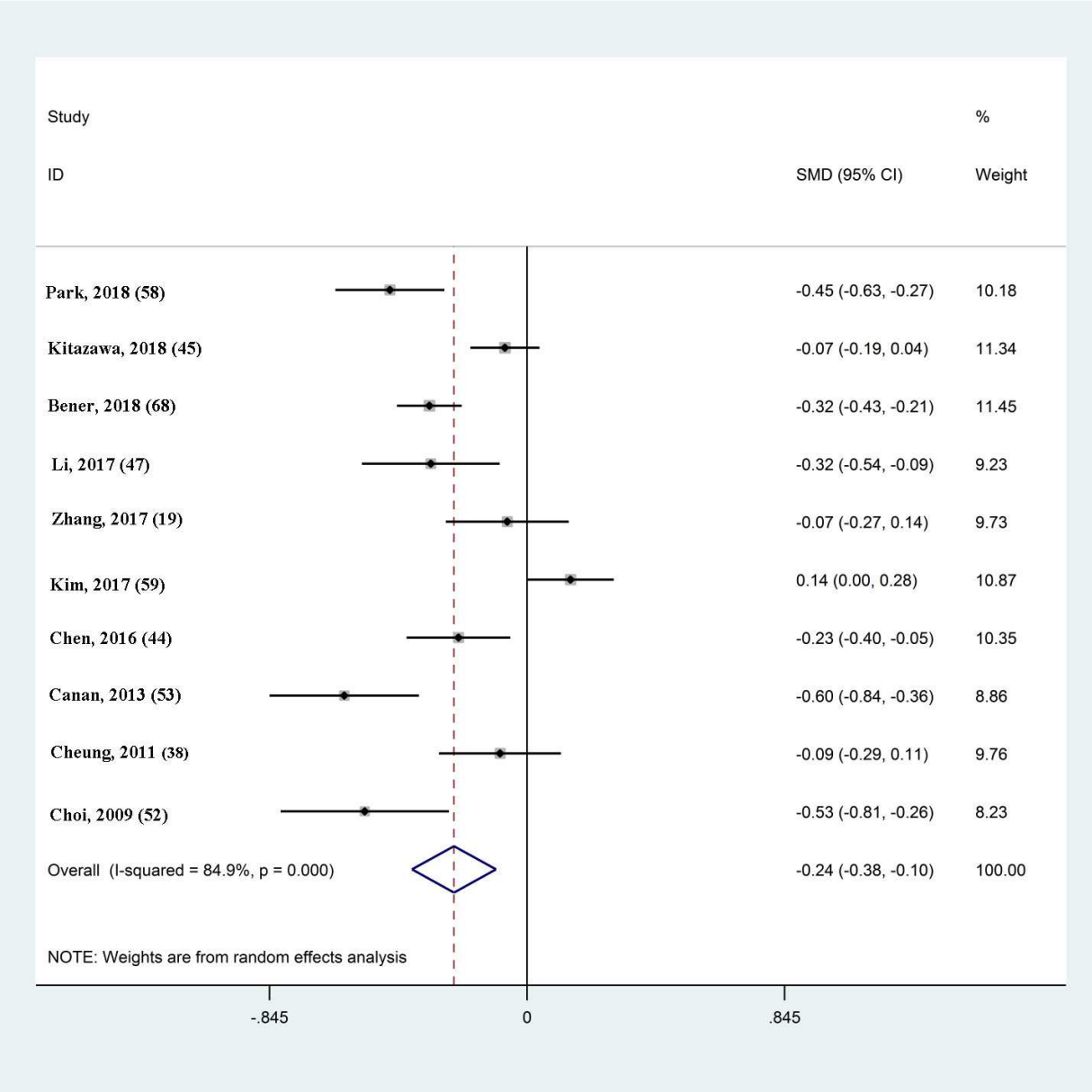

Figure 4. Forest plot of overall SMDs comparing sleep duration among internet-addicted users and normal users

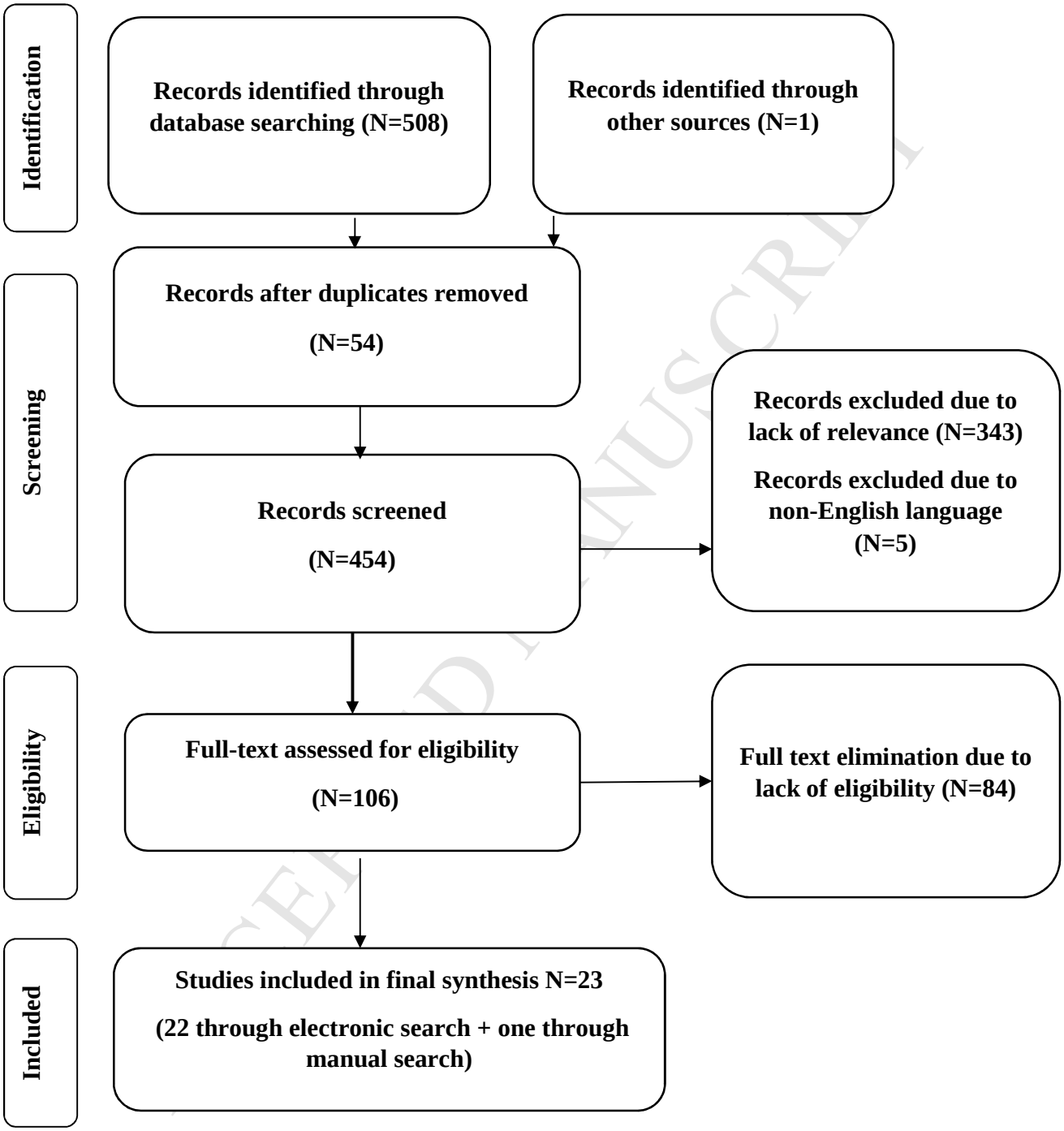

Figure 1. PRISMA flow diagram of selected studies

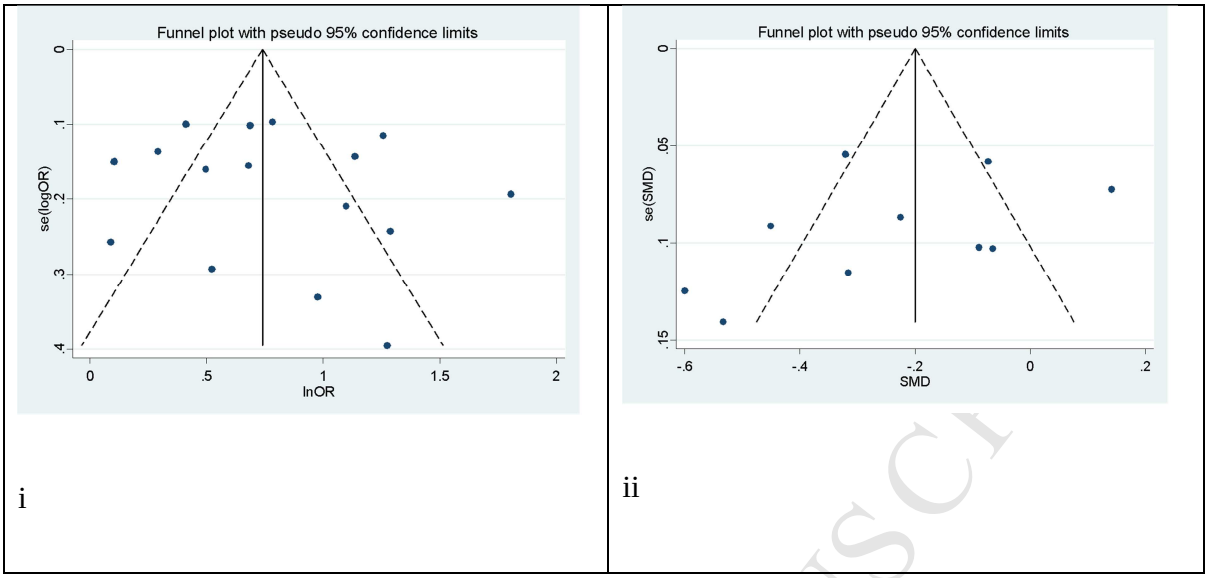

Figure 5. Funnel plots for assessing publication bias within studies related to (i) sleep problems and (ii) sleep duration

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