A systematic review with meta-analyses of the relationship between recurrent binge eating and sleep parameters

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Competing Interests statement

Amanda Sainsbury and Zubeyir Salis own 50% each of the shares in Zuman International, a company which receives royalties and other payments for educational resources and services about adult weight management and research methodology. Amanda Sainsbury has also received presentation fees and travel reimbursements from Eli Lilly and Co, the Pharmacy Guild of Australia, Novo Nordisk, the Dietitians Association of Australia, Shoalhaven Family Medical Centres, the Pharmaceutical Society of Australia, and Metagenics, and served on the Nestlé Health Science Optifast VLCD advisory board from 2016 to 2018. Phillipa Hay

receives/has received sessional fees and lecture fees from the Australian Medical Council, Therapeutic Guidelines publication, and HETI New South Wales Institute of Psychiatry and royalties/honoraria from Hogrefe and Huber, McGraw Hill Education, and Blackwell Scientific Publications, Biomed Central and PlosMedicine and she has received research grants from the NHMRC and ARC. She is Chair of the National Eating Disorders Collaboration Steering Committee in Australia (2012-) and was Member of the ICD-11 Working Group for Eating Disorders (2012-2019) and was Chair Clinical Practice Guidelines Project Working Group (Eating Disorders) of RANZCP (2012-2015). She has prepared a report under contract for Shire Pharmaceuticals in regard to Binge Eating Disorder (July 2017) and consulting fees for education of doctors from Takeda Pharmaceuticals. All views in this paper are her own. Charles Morin has research contracts with Eisai, Idorsia, Lallemand Health Consulting, and is an advisor for Eisai, Idorsia, Pear Therapeutics, and Sunovion.

Abstract

Background: Sleep problems are known to compound the negative effects of other health issues, such as eating disorders and the associated behaviour of binge eating. Previous studies suggested associations between binge eating and sleep problems, but the strength of the relationship is unknown. **Methods**: We conducted a systematic review with meta-analyses examining the relationship between binge eating and sleep parameters. We searched for studies in Scopus, PubMed, and PsycInfo. The quality of evidence, including risk of bias, was assessed with adaptations of the Newcastle-Ottawa Scale and the Joanna Briggs Institute Critical Appraisal Checklist for Quasi-Experimental Studies, depending on study design. Data was synthesised as the difference in sleep between people who did or did not have binge eating. **Results**: Thirty-one reports of studies met our eligibility criteria. Results are presented in 12 meta-analyses. In the 7 reports of studies (with 4448 participants) that assessed poor overall sleep quality, we found poorer overall sleep quality in people with binge eating compared to people without binge eating, with a standardized mean difference of 0.77 (95% confidence interval [CI] 0.61 to 0.92; $P < 0.001$), which is a large effect size. Additionally, we found evidence that people with binge eating had significantly greater hypersomnia/daytime sleepiness (7 reports of studies with 4370 participants), insomnia (5 reports of studies with 12733 participants), and difficulty falling asleep (3 reports of studies with 4089 participants) compared to people without binge eating, with moderate effect sizes (standardized mean differences of 0.57 to 0.66). **Conclusions**: People with binge eating exhibit poorer overall sleep quality compared to people without binge eating, and may also exhibit greater hypersomnia/daytime sleepiness, insomnia, and difficulty falling asleep. It is recommended that healthcare professionals routinely screen for poor overall sleep quality when treating people with binge eating – and address sleep difficulties when present. **Keywords**: Binge eating; eating disorders; sleep; sleep disorders; systematic review; meta-analysis.

Introduction

Binge eating is a common and problematic trans-diagnostic behaviour in people with eating disorders. A binge eating episode is currently defined by two main features: 1) the ingestion, in a discrete period of time (e.g., a 2-hour period), of an amount of food that is certainly larger than what most people would eat in a similar period of time under similar circumstances; and 2) a sense of loss of control over eating during the episode (i.e., a feeling that one cannot stop eating or control what/how much one is eating) (1). The occurrence of binge eating episodes is a defining feature of eating disorders such as binge eating disorder (BED), bulimia nervosa (BN), anorexia nervosa (AN) of the binge/purge type, and additional eating disorder presentations classified as "other specified feeding or eating disorders" (OSFED) (e.g., BED/BN of low frequency and/or limited duration) (1).

Binge eating episodes are commonly associated with medical and psychiatric conditions (1). For instance, recurrent binge eating was found to be associated with obesity, diabetes, chronic pain, fibromyalgia, gastrointestinal problems such as irritable bowel syndrome, nutritional deficiencies, reproductive health difficulties, and depression (2-9). Moreover, a narrative review discussing the relationship between eating disorders and sleep problems suggested that people with eating disorder behaviors exhibit a greater occurrence of disrupted sleep, in comparison to people without eating disorder behaviours (10). Previous studies also found associations between disinhibited eating behaviors (e.g., overeating in the presence of palatable foods or psychological stress) with poor sleep quality and obesity (11, 12). Additionally, another eating-related condition that can be associated with sleep problems (i.e., short sleep duration and poor sleep quality) is night eating syndrome – a disorder characterized by evening

hyperphagia and/or nocturnal ingestion (13). Finally, a narrative review on the medical complications of BED suggested association of BED with multiple sleep abnormalities (7).

To the best of our knowledge, no systematic search of the literature has been conducted to investigate the relationship between binge eating and sleep problems, but would be important for several reasons. Firstly, poor sleep in itself impacts on mental health. For instance, an association was found between insomnia and poor mental health-related quality of life in a large representative community-based study with 2977 adults in Australia (14). Secondly, sleep problems can contribute to unhealthy eating behaviors via biological, cognitive, emotional and behavioral mechanisms, as outlined in a narrative review of the literature (15). That narrative review showed that there is a need for further research on how these mechanisms influence the relationship between sleep problems and eating behaviors (15). Thirdly, therapy manuals for eating disorders do not include interventions to improve sleep problems, and vice-versa. Notably, the "gold standard" guide for the treatment of eating disorders, which is cognitive behavior therapy – enhanced (CBT-E), does not include interventions to reduce any co-morbid sleep difficulties in people with eating disorders (16). Thus, clinicians that are specialized in the treatment of eating disorders may not address sleep difficulties that their clients may face, but ongoing sleep difficulties could exacerbate mental and physical health issues related to the eating disorder. Hence, in this systematic review we undertook a comprehensive investigation into the potential association between binge eating and sleep parameters to determine whether people with binge eating have an elevated risk of sleep difficulties. If yes, then it may be potentially appropriate to add sleep improvement interventions in therapy manuals for eating disorders such as BED.

Methods

Eligibility criteria

We included studies that presented statistical analyses assessing potential relationships between binge eating and sleep parameters in humans. There were no restrictions on study designs, year of publication, language, types of sleep parameters investigated, or sample characteristics (i.e., age or clinical conditions). Studies with the following characteristics were excluded: not published in peer-reviewed journals, literature reviews, conference abstracts, based on animals. Studies reporting relevant outcomes on sleep that had been shown in a previous (included) study that assessed the same sample were excluded, unless the later report of the study was more informative for the relevant outcomes on sleep, in which case the later report of the study was used. We also excluded studies that examined the relationship between binge eating and night eating syndrome. These studies were excluded because night eating syndrome involves a combination of sleep and eating disorder features in itself, and this could be a confounding variable for our review (17).

Information sources

We searched three databases, namely Scopus, PubMed, and PsycInfo, from inception of each database until February 2021. We also searched for additional studies in the reference lists of all full-text studies that met the eligibility criteria for inclusion in this systematic review.

Search strategy

The same search strategy combining two groups of keywords in English was used in the three databases, as follows: ("binge eating" OR "binge eating disorder") AND ("sleep" OR "sleep problem" OR "sleep problems" OR "sleep disorder" OR "sleep disturbance" OR "insomnia" OR "hypersomnia" OR "obstructive sleep apnea disorder" OR "apnea" OR "circadian rhythm disorder"). The searches in the PubMed and PsycInfo databases did not include any restrictions, and the search in Scopus was limited by document type to exclude reviews, book chapters, editorials, and letters.

Selection process

Titles and abstracts of the studies identified in the above search were independently screened by two authors (LPG and LP). The full texts of potentially eligible studies were obtained and were independently screened by the same authors according to the inclusion and exclusion criteria listed above. Discrepancies over which studies to include in the review were resolved by consensus with a third and fourth author (FQdL and RERF). Potentially eligible studies identified from the reference lists of the included studies (as mentioned above) were also screened via the same process. A detailed overview of each stage of the literature search and screening is shown in Figure 1.

Data collection process, data items and effect measures

Two authors (LPG and LP) extracted the following descriptive information from each study: first author family name and publication year; aims; methodological design; sample characteristics; measures of binge eating/sleep problems; and whether any relationships between binge eating and a sleep parameter were found (Table 1). Table 1 also shows information about whether the study was included in a meta-analysis.

The above descriptive information extracted from each study was reviewed by two other authors (FQdL and RERF). Next, FQdL and RERF extracted data from the included studies for 12 separate meta-analyses assessing the relationship between binge eating and the following variables: 1) poor overall sleep quality; 2) hypersomnia/daytime sleepiness; 3) insomnia; 4) difficulty falling asleep; 5) difficulty staying asleep; 6) problems waking up too early; 7) snoring; 8) sleep duration; 9) sleep efficiency; 10) sleep latency; 11) wake time after sleep onset; and 12) narcolepsy accompanied by cataplexy. The data was required from each publication in a format that allowed us to calculate the difference between groups (i.e., as standardized mean difference or difference in means) for the sleep variable of interest between groups of people with or without binge eating, or – for the 12th meta-analysis listed above – the standardized mean difference in binge eating between groups of people with or without narcolepsy accompanied by cataplexy. We also required data from each publication to be in a format that allowed us to calculate the 95% confidence interval of the difference between groups. Only one study that was eligible for a meta-analysis had data that was not presented in the published report in the format needed for meta-analysis (18), and we emailed the corresponding author of that study to subsequently obtain the relevant data. Some studies

assessed the relationship between binge eating and a variety of sleep parameters, and data from these studies were included in as many meta-analyses as relevant. Finally, findings of studies that reported outcomes that could not be included in a meta-analysis for issues that could not be solved by simply accessing the data were analysed qualitatively. Such issues include studies that assessed outcomes or used experimental paradigms that were too different to studies included in one of the 12 meta-analyses.

Study risk of bias assessment

The risk of bias of the studies included in this review was assessed independently by two authors (FQdL and RERF) using different scales. We used the adaptations of the Newcastle-Ottawa Scale for reports of cross-sectional studies, case-control studies, and cohort studies; and we used the Joanna Briggs Institute Critical Appraisal Checklist for quasi-experimental studies.

Synthesis methods and certainty assessments

The meta-analyses were conducted using Comprehensive Meta-Analysis (CMA) version 3.3.070. This provided the summary effect size (difference in means or standardized difference in means) and its 95% confidence interval for each meta-analysis. We set up the data so a positive difference in means or standardized difference in means showed a higher mean in the group with binge eating (or – for the 12th meta-analysis – with narcolepsy accompanied by cataplexy) than in the group without binge eating (or without narcolepsy accompanied by

cataplexy). For meta-analyses where the summary effect size was expressed in standardized difference in means, we used Cohen's interpretation of effect sizes as small (0.2), medium (0.5), and large (0.8) (19). We assumed that the studies included in the meta-analyses were heterogeneous (e.g., due to differences in participants and settings etc), therefore we chose the random-effects model in estimation of summary effect sizes for all meta-analyses, analysed using the method of restricted maximum-likelihood (REML). Moreover, we used the Q, I^2 and *Tau* statistics to assess heterogeneity among studies in each meta-analysis. In addition to 95% confidence intervals, which provided 95% certainty in the true summary effect size of the studies included in each meta-analysis, we also assessed certainty of evidence by calculating 95% prediction intervals, which provide 95% certainty as to the likely effect size of future studies similar to the ones included in the meta-analyses. To calculate prediction intervals, we used a CMA add-on (i.e., CMA Prediction Intervals), which required inputs from each meta-analysis of: the number of study reports; the summary effect size; the upper limit of the 95% confidence interval; and Tau^2. In terms of exploring possible sources of any heterogeneity among the studies included in the meta-analyses, we did not make any a priori plans to conduct subgroup analyses or meta-regression.

Reporting bias assessment

We used a statistical test, namely the Egger's test, and two graphical tests, namely: visual inspection of funnel plot symmetry; and Trim and Fill analyses, to assess for publication bias and small study effects among the studies included in each meta-analysis.

Results

Study selection

We found 675 studies from our databases searches (Figure 1). After duplicates were removed, 472 records of studies were available for screening at the level of title and abstract. Next, we retrieved and evaluated the full texts of 31 studies and 12 were excluded. These 12 studies were excluded because 2 were not full-text scientific reports, 2 were reports of narrative reviews (20, 21), 6 were studies that did not assess binge eating (22-27), 1 was a study that did not assess any sleep pattern (28), and 1 record of study (29) was from a study that was reported in another publication that was included in this systematic review (30). This left 19 studies for inclusion. After reading the reference lists of these 19 included studies we found 12 additional studies that met the eligibility criteria. In total, 31 studies were included in the review.

INSERT FIGURE 1 HERE

Study characteristics

Characteristics of the included studies are listed in Table 1 and below. Population groups examined in the studies included adults, adolescents, or children; and sample sizes ranged from 16 to 72435 participants. The studies included in the review employed different methodical designs (i.e., cross-sectional, case-control, cohort, and quasi-experimental), as well as objective

and subjective outcome measures (e.g., actigraphy, Pittsburgh Sleep Quality Index (31)) (see Table 1). Thirty studies were published in English, and 1 study was published in Portuguese. The relevant information from the study that was published in Portuguese was translated into English by the first author (FQdL), who is fluent in Portuguese and English.

INSERT TABLE 1 HERE

Risk of bias in studies

The quality of the 31 studies included in this review is shown in Table 2. A total of 30 studies were assessed with a version of the Newcastle-Ottawa Scale. There is no consensus on a cut-off point defining quality for the Newcastle-Ottawa Scale, nonetheless previous studies suggested that scores of 7 or more can be used to define high-quality studies (32, 33). The Newcastle-Ottawa Scale adapted for cross sectional studies was used for 25 studies. All these 25 studies received a total score of 6, 7 or 8. The Newcastle-Ottawa Scale adapted for case-control studies was used for 4 studies. All these 4 studies received a total score of 6 or 7. Additionally, the Newcastle-Ottawa Scale adapted for Cohort Studies was used to assess the quality of 1 study, which received a total score of 9. Finally, 1 study was positively evaluated in all criteria of the Joanna Briggs Institute Critical Appraisal Checklist for Quasi-Experimental Studies.

INSERT TABLE 2 HERE

Results of syntheses

Of the 31 studies included in this review, 20 provided data that could be used in meta-analyses (Table 3). There were 12 meta-analyses in total. Of the 31 studies included in this systematic review, 11 did not provide data that could be used in meta-analyses (Table 1). Thus, these 11 studies were qualitatively assessed.

INSERT TABLE 3 HERE

Binge eating was associated with poorer overall sleep quality

The relationship between binge eating and poor overall sleep quality was assessed in a meta-analysis that included 7 studies (18, 34-39) and 4448 participants in total. These studies received a score of 6 or 7 in adaptations of the Newcastle-Ottawa Scale. We found poorer overall sleep quality in people with binge eating in comparison to people without binge eating, with a standardised mean difference of 0.77 (95% confidence interval [CI] 0.61 to 0.92; $P<0.001$), which is considered a large effect size (19) (Figure 2). We found no evidence of heterogeneity among the studies included in this meta-analysis (P value for X^2 test on Q = 0.568, Table 3). The 95% prediction interval (PI) was 0.61 to 0.92, which is the same as the 95% CI because the between-study standard deviation (*Tau*) was 0.000, indicating that future similar studies will likely show poorer overall sleep quality in people with binge eating versus people without binge eating.

INSERT FIGURE 2 HERE

Binge eating was associated with hypersomnia/daytime sleepiness, insomnia, and difficulty falling asleep

People with binge eating also showed greater hypersomnia/daytime sleepiness, insomnia, and difficulty falling asleep compared to people without binge eating, and the effect sizes were moderate.

The relationship between binge eating and hypersomnia/daytime sleepiness was assessed in a meta-analysis that included 7 studies and 4370 participants in total (18, 36-38, 40-42). These studies received a score of 6 or 7 in adaptations of the Newcastle-Ottawa Scale. We found a statistically significant (P=0.002) moderate effect size expressed in a standardised mean difference of 0.57 (95% CI 0.20 to 0.94), showing that people with binge eating experienced greater hypersomnia/daytime sleepiness in comparison to people without binge eating (Figure 3). Nonetheless, we also found significant heterogeneity in the studies included in this meta-analysis (95% PI of -0.47 to 1.62; P value for X^2 test on Q = 0.036, Table 3). This PI indicates that future similar studies are unlikely to show a significant difference between people with or without binge eating in terms of hypersomnia/daytime sleepiness. As there were more than 3 of each study type in this meta-analysis (i.e., 3 case-control studies, and 4 cross-sectional studies), we performed a subgroup analysis of the different study types. The subgroup analysis showed that there is no subgroup effect by study type (see Supplementary material).

INSERT FIGURE 3 HERE

The relationship between binge eating and insomnia was assessed in a meta-analysis that included 5 studies and 12733 participants in total. Four out of these 5 studies received a score of 6 or 7 in the Newcastle-Ottawa Scale adapted for cross sectional studies (43-46), and 1 study was assessed positively in all criteria from the Joanna Briggs Institute Critical Appraisal Checklist for Quasi-Experimental Studies (30). We found a statistically significant (P<0.001) moderate effect size expressed in a standardised mean difference of 0.66 (95% CI 0.36 to 0.95), showing that people with binge eating experienced greater insomnia in comparison to those without binge eating (Figure 4). However, we also found significant heterogeneity in the studies included in this meta-analysis (95% PI of -0.30 to 1.61; P value for X^2 test on Q < 0.001, Table 3). Thus, while the studies in this meta-analysis showed more insomnia in people with binge eating versus people without binge eating, it is unlikely that future similar studies would show a significant difference.

INSERT FIGURE 4 HERE

The relationship between binge eating and difficulty falling asleep was assessed in a meta-analysis that included 3 studies and 4089 participants in total (38, 41, 42). These studies received a score of 7 on the Newcastle-Ottawa Scale adapted for Cross Sectional Studies. We found a statistically significant (P<0.001) moderate effect size expressed in a standardised mean difference of 0.62 (95% CI 0.31 to 0.94), showing that people with binge eating experienced greater difficulty falling asleep in comparison to those without binge eating

(Figure 5). However, we also found significant heterogeneity in the studies included in this meta-analysis (95% PI of -1.68 to 2.92; *P* value for X^2 test on Q = 0.338, Table 3).

INSERT FIGURE 5 HERE

The heterogeneity found in the meta-analyses on hypersomnia/daytime sleepiness, insomnia, and difficulty falling asleep, can potentially be explained by the wide variability in sample characteristics in the included studies, particularly with regards to differences in clinical conditions (e.g., presence or absence of AN, BN, BED, obesity) or participants age (i.e., adults, adolescents, or children).

Binge eating was not associated with difficulty staying asleep, problems waking up too early, snoring, or differences in sleep duration, sleep efficiency, sleep latency, or wake time after sleep onset

There were no apparent differences between people with or without binge eating in difficulty staying asleep, problems waking up too early, snoring, sleep duration, sleep efficiency, sleep latency, or wake time after sleep onset.

The relationship between binge eating and difficulty staying asleep was assessed in a meta-analysis that included 3 studies and 99 participants in total (37, 41, 42). All these 3 studies received a score of 7 on the Newcastle-Ottawa Scale adapted for cross sectional studies. These

studies used the same tool for measuring difficulty staying asleep (the Mini-Sleep Questionnaire), and so the results are expressed as a difference in mean score rather than as a standardised mean difference. We found no statistically significant (*P*=0.097) difference between groups, with the difference in mean scores being 0.52 (95% CI -0.09 to 1.13), showing that there was no difference in scores for difficulty in staying asleep between people with or without binge eating. We also did not find any evidence of heterogeneity in the studies included in this meta-analysis (95% PI of -0.09 to 1.13; *P* value for X^2 test on Q = 0.585, Table 3).

The relationship between binge eating and problems waking up too early was assessed in a meta-analysis that included 3 studies and 4089 participants in total (38, 41, 42). These studies received a score of 7 on the Newcastle-Ottawa Scale adapted for Cross Sectional Studies. We found no statistically significant (*P*=0.375) difference in problems waking up too early between people with or without binge eating, as expressed in a standardised mean difference of 0.23 (95% CI -0.28 to 0.74). However, we also found substantial heterogeneity in the studies included in this meta-analysis (95% PI of -5.14 to 5.60; *P* value for X^2 test on Q = 0.117, Table 3).

The relationship between binge eating and snoring was assessed in a meta-analysis that included 3 studies and 99 participants in total (37, 41, 42). These studies received a score of 7 on the Newcastle-Ottawa Scale adapted for cross sectional studies. We found no statistically significant (*P*=0.126) difference in mean score on the snoring scale (which was used in all studies) between people with binge eating versus people without binge eating, with the difference in means being 0.69 (95% CI -0.19 to 1.57). Additionally, we did not find evidence

of heterogeneity in the studies included in this meta-analysis (95% PI of -6.21 to 7.59; *P* value for X^2 test on Q = 0.308, Table 3).

The relationship between binge eating and sleep duration was assessed in a meta-analysis that included 11 studies and 47945 participants in total. Ten out of these 11 studies received a score of 6, 7, or 8 on the Newcastle-Ottawa Scale adapted for Cross Sectional Studies (18, 37, 39-42, 47-50), and 1 study received a score of 6 on the Newcastle-Ottawa Scale for case-control studies (36). We found no statistically significant (*P*=0.452) effect size, expressed in a standardized mean difference of 0.06 (95% CI -0.10 to 0.24), showing that there was no difference in sleep duration between people with or without binge eating. We also found substantial heterogeneity in the studies included in this meta-analysis (95% PI of -0.43 to 0.56; *P* value for X^2 test on Q < 0.001, Table 3). As there were more than 3 of each study type in this meta-analysis (i.e., 3 case-control studies, and 8 cross-sectional studies), we performed a subgroup analysis of the different study types (Supplementary materials). In case control studies, there was evidence of difference in sleep duration between groups with or without binge eating (standardized mean difference of -0.53 (95% CI -0.93 to -0.14, *P*=0.01)), while in cross-sectional studies there was no difference in sleep duration between groups with or without binge eating (standardized mean difference of -0.17 (95% CI = -0.03 to 0.38, *P* = 0.10)).

The relationship between binge eating and sleep efficiency was assessed in a meta-analysis that included 7 studies and 290 participants in total. Six out of these 7 studies received a score of 7 or 8 on the Newcastle-Ottawa Scale adapted for Cross Sectional Studies (37, 39, 41, 42, 48, 49), and 1 study received a score of 6 on the Newcastle-Ottawa Scale for case-control studies

(36). We found no statistically significant (*P*=0.649) standardized mean difference between people with or without binge eating: 0.11 (95% CI -0.37 to 0.60). We also found substantial heterogeneity in the studies included in this meta-analysis (95% PI of -1.40 to 1.63; *P* value for X^2 test on Q < 0.001, Table 3). As there were more than 3 of each study type in this meta-analysis (i.e., 3 case-control studies, and 4 cross-sectional studies), we performed a subgroup analysis of the different study types (see supplementary materials). The subgroup analysis showed that the effect of binge eating on sleep efficiency did not differ by study type (and there was no effect of binge eating on sleep efficiency).

The relationship between binge eating and sleep latency was assessed in a meta-analysis that included 6 studies and 247 participants in total. Five out of these 6 studies received a score of 6, 7, or 8 on the Newcastle-Ottawa Scale adapted for Cross Sectional Studies (18, 39, 41, 48, 49), and 1 study received a score of 6 on the Newcastle-Ottawa Scale for case-control studies (36). We found no statistically significant (*P*=0.430) difference in means of between people with or without recurrent binge eating: -1.86 (95% CI -6.50 to 2.77) minutes. We also found substantial heterogeneity in the studies included in this meta-analysis (95% PI of -16.88 to 13.15 minutes; *P* value for X^2 test on Q < 0.001, Table 3).

The relationship between binge eating and wake time after sleep onset was assessed in a meta-analysis that included 3 studies and 99 participants in total (37, 41, 42). These studies received a score of 7 on the Newcastle-Ottawa Scale adapted for Cross Sectional Studies. We found no statistically significant (*P*=0.574) difference in means in wake time after sleep onset between people with or without binge eating: 10.74 (95% CI -26.67 to 48.14) minutes. We also found

substantial heterogeneity in the studies included in this meta-analysis (95% PI of -438.85 to 460.32 minutes; *P* value for X^2 test on Q < 0.001, Table 3).

The substantial heterogeneity found in the meta-analyses on problems waking up too early, sleep duration, sleep efficiency, sleep latency, and wake time after sleep onset can potentially be explained by differences in sample characteristics, namely participants' age (i.e., adults, adolescents, or children), and clinical conditions (e.g., AN, BED, obesity), as well as assessment measures (e.g., PSQI, actigraphy) employed in the included studies.

Binge eating was associated with narcolepsy accompanied by cataplexy

The relationship between binge eating and narcolepsy accompanied by cataplexy was assessed in a meta-analysis that included 2 studies and 126 participants in total. Note that the results for narcolepsy accompanied by cataplexy are reported here in line with the data that was available from the studies included in this systematic review. These studies compared the occurrence of binge eating in people with or without narcolepsy accompanied by cataplexy (rather than the occurrence of narcolepsy accompanied by cataplexy in people with or without binge eating). These studies received a score of 7 on the adaptations of the Newcastle-Ottawa Scale for cross sectional studies and for case-control studies (51, 52). We found a statistically significant (*P*=0.002) medium effect size expressed in a standardized mean difference in binge eating scores of 0.55 (95% CI 0.20 to 0.91), showing that people with narcolepsy accompanied by cataplexy experienced greater binge eating in comparison to those without narcolepsy accompanied by cataplexy. We were not able to calculate the 95% prediction interval for this

meta-analysis because of the insufficient number of studies that were included, however the studies did not show heterogeneity (*P* value for X^2 test on Q = 0.782, Table 3).

Certainty of evidence and reporting biases

There were 11 of the 12 meta-analyses that included sufficient studies (3 or more) to assess publication bias and small study effects, and no such evidence was found (see Supplemental material). For the remaining meta-analysis, which investigated the relationship between binge eating and narcolepsy accompanied by cataplexy, it was not possible to assess reporting biases because of the small number of studies included (2 studies).

Studies that were not included in a meta-analysis

Eleven of the 31 studies included in this systematic review did not report data that was suitable for inclusion in a meta-analysis, and so we assessed them qualitatively. The most relevant findings from these 11 studies are described below.

Three of these 11 qualitatively-assessed studies compared the occurrence of sleep problems in people with or without binge eating (53-55). Insomnia was investigated in one study (53) which assessed a population-based sample of 2163 adult female twins and found a greater occurrence of insomnia – among other neurovegetative symptoms – in women with binge eating in comparison to women without binge eating. This is in line with our meta-analysis which found

greater insomnia in people with versus without binge eating. Difficulty falling asleep and difficulty staying asleep were investigated in one study (54) of 400 adolescent and adult females with AN or BN, and were found to be greater in those participants with binge eating/purging behaviors in comparison to those without binge eating/purging behaviors. This finding is broadly in consonance with our meta-analyses which found greater difficulty falling asleep and (a non-statistically-significant trend towards) greater difficulty staying asleep in people with versus without binge eating. Finally, snoring – like the results in our meta-analysis on snoring – was found to be no different in people with binge eating in comparison to those without binge eating, in a study of people with AN, BN, or an eating disorder not otherwise specified (EDNOS) (55). Overall, these studies provided additional evidence of insomnia or difficulty falling asleep in people with binge eating (in congruence with two of our meta-analyses) and showed that difficulty staying asleep can also be associated with binge eating.

In addition to the four sleep problems that were investigated in our meta-analyses (i.e., insomnia, difficulty falling asleep, difficulty staying asleep, or snoring), two of the 11 studies that we assessed qualitatively (56, 57) investigated sleep problems that were not included in any of our meta-analyses. These sleep problems were study-specific constructs of "sleep problems", "sleep dissatisfaction", and "poor sleep health". Overall, these study-specific constructs of sleep problems were more prevalent in people with versus people without binge eating. Specifically, the Norwegian Mother and Child Cohort Study found that participants with BED symptoms showed greater sleep problems during the first 18 weeks of pregnancy, and more sleep dissatisfaction at 18 months after child birth, in comparison to those without any eating disorder symptoms (56). Another study involving 212 adults enrolled in a commercial weight loss program found that, controlling for age and BMI, adults with BN or BED were more likely to report poor sleep health in comparison to adults without BN or BED

(57). Overall, these two studies (56, 57) are broadly consistent with the results from our meta-analyses, in that there were more sleep problems in people with binge eating in comparison to those without binge eating.

One of the 11 studies that we assessed qualitatively (58), similar to the two above-mentioned studies (56, 57), also investigated a study-specific construct of "sleep disturbances". However, instead of treating binge eating as a categorical variable (i.e., by comparing people with versus people without binge eating), this study treated binge eating behaviors as a continuous variable. Specifically, that study assessed 870 university students in Portugal with the Eating Attitudes Test-40, and the sum of the scores for the items on bulimic behaviour/binge eating and bulimic behaviour/purgative behaviour were found to be positively and significantly correlated with sleep disturbances (also a continuous variable) in male (but not female) students (58). Again, the findings from this qualitatively-assessed study (58) is broadly consistent with the results of our meta-analyses, in that people with binge eating have more sleep problems than people without binge eating.

Sleep duration was investigated in two of the 11 studies that could not be included in a meta-analysis (56, 59), each study using a different analytical approach. One of these two qualitatively-assessed studies compared sleep duration in people with or without binge eating, similarly to one of our meta-analyses. This study examined data from the Norwegian Mother and Child Cohort Study and found that in the third semester of pregnancy, women with incident symptoms of BED had a longer sleep duration in comparison to those without eating disorders (56). This study contrasted with the result of our meta-analysis, in which there were no significant differences in sleep duration between people with binge eating in comparison to

people without binge eating. The other study used a different analytical approach, in that the occurrence of binge eating was examined in people with different sleep duration (56, 59). This study investigated university students at the United States and found a greater occurrence of binge eating in students that sleep < 8 hours per night in comparison to those that sleep ≥ 8 hours per night (59). It is noteworthy that we did not undertake meta-analysis examining binge eating in people with different sleep duration in this systematic review, because this (59) is the only study that investigated binge eating and sleep in this way.

Two qualitatively-assessed studies investigated the occurrence of binge eating in people with the sleep-related breathing disorder of obstructive sleep apnea (60, 61). One of these two studies found that candidates for bariatric surgery that had obstructive sleep apnea had greater odds of a past diagnosis of BED in comparison to those without obstructive sleep apnea (60). Similarly, the other of the two studies (61) found a 6.2% incidence of BED in a sample of 81 adults from Germany with obstructive sleep apnea prior to treatment for their sleep problem, with 6.2% being higher than the 0.9% prevalence of BED found in the general population of high-income countries (62). Overall, these studies showed an elevated occurrence of past or current BED in people with a sleep duration of < 8 hours per night (59) or with obstructive sleep apnea (60, 61). Note that we did not include a meta-analysis that examined binge eating in people with obstructive sleep apnea in this systematic review.

The final one of the 11 studies that we qualitatively reviewed compared binge eating in people with or without narcolepsy. This study found no difference in the prevalence of BED or BN in 196 people with only narcolepsy in comparison to those without narcolepsy/cataplexy (63). Overall, this qualitatively-reviewed study (63), in combination with the results from our meta-

560 analysis, suggests that only people with narcolepsy accompanied by cataplexy have greater
561 binge eating in comparison to those without narcolepsy/cataplexy.

562

563 Taken together, the results from our qualitative assessment of the 11 studies that could not be
564 included in a meta-analysis were broadly consistent with the results from our meta-analyses,
565 in that people with binge eating demonstrated more sleep problems than people without binge
566 eating, and that people with a shorter sleep duration or sleep apnea (but not narcolepsy
567 unaccompanied by cataplexy) had a greater occurrence of past or present binge eating
568 behaviors.

569

570 **Discussion**

571

572 Our systematic review with meta-analyses showed that people with binge eating exhibit poorer
573 overall sleep quality – and may also exhibit greater hypersomnia/daytime sleepiness, insomnia,
574 and difficulty falling asleep – in comparison to people without binge eating. Moreover, this
575 work showed a greater occurrence of binge eating in people with the sleep problem of
576 narcolepsy accompanied by cataplexy in comparison to people without narcolepsy/cataplexy.
577 Finally, qualitative analyses of 11 studies that were included in our systematic review but were
578 not suitable for inclusion in a meta-analysis showed results that were broadly consistent with
579 our meta-analyses: people with binge eating had more sleep problems in comparison to those
580 without binge eating; and people with a shorter sleep duration (i.e., < 8 hours per night) or sleep
581 apnea had a greater occurrence of past or present binge eating.

582

These findings have clinical implications. The co-occurrence of poorer overall sleep quality and other sleep problems with binge eating holds the potential to exacerbate binge eating-associated health problems (e.g., obesity) and/or to jeopardize binge eating treatments. Indeed, as outlined in the Introduction section, poor sleep in itself impacts on mental health (14), and sleep problems can contribute to unhealthy eating behaviors via biological, cognitive, emotional and behavioral mechanisms (15). Therefore, healthcare professionals working with clients with conditions involving binge eating could do well to screen their clients for potential sleep problems and to provide referral to a sleep study (polysomnography) if sleep problems are suspected. Suitable and fast screening tools for potential sleep problems are the Pittsburgh Sleep Quality Index (31) and the Mini-Sleep Questionnaire (64), both of which are available in multiple languages and are administered as self-report surveys (e.g., which could be completed by a client in a waiting room). Moreover, healthcare professionals specialized in the treatment of eating disorders could do well to up-skill in therapeutical interventions for certain sleep problems, given that clients may not have resources to consult separate healthcare professionals for eating disorders as well as for sleep problems at the same time. For instance, interventions such as sleep hygiene education and cognitive behavior therapy for insomnia can be learned and implemented by a variety of healthcare professionals (not just sleep specialists), and can improve sleep that is of poor quality (65, 66). It is noteworthy that the guide for the eating disorder treatment with the greatest evidence of effectiveness – CBT-E – does not mention sleep problems as a major factor in the maintenance of binge eating (16). Instead, the main factors that maintain binge eating in people with eating disorders, according to the CBT-E guide, are: the overvaluation of body shape/weight; strict dieting; and adverse events and moods (16). Future research of relevance and interest would thus be to investigate whether concurrent treatment for eating disorders involving binge eating and any comorbid sleep problems results in better health outcomes than treatment of the eating disorder alone.

This systematic review with meta-analyses has limitations and strengths. Our systematic review was limited in that the analyses did not allow determination of causal relationships. Thus, we cannot ascertain whether binge eating can cause sleep problems, or vice-versa. Future interventional research alluded to above could help ascertain whether a causal relationship exists, by determining whether binge eating is reduced by co-treatment of binge eating and concurrent sleep problems, and vice versa. Another limitation is that some studies included in our systematic review examined small sample sizes, did not precisely inform the measures that were used to assess binge eating, or employed unconventional measures to assess binge eating or sleep parameters. For instance, only 7 out of the 31 studies included in our systematic review employed objective sleep measures (e.g., actigraphy), and the remaining studies employed subjective measures of sleep parameters (e.g., Pittsburgh Sleep Quality Index (31), Mini-Sleep Questionnaire (64), Epworth Sleepiness Scale (67), Insomnia Severity Index (68)). Alongside these limitations, our review has several strengths. Firstly, our review was comprehensive; we investigated relationships between binge eating and a variety of sleep problems and parameters, and we included samples with diverse characteristics (e.g., children with or without binge eating, adolescents, and adults with or without eating disorders, adult twins with or without binge eating, adults with sleep disorders). Another strength of our review is that it included studies with diverse methodological designs (i.e., cross-sectional studies, quasi-experimental studies, case-control studies), which enabled examination of the relationships between binge eating and sleep parameters from complementary perspectives. Finally, our systematic review with meta-analyses followed the principles of the most up-to-date (i.e., published in the year 2021) Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (69).

In conclusion, our systematic review with meta-analyses found that people with recurrent binge eating experience poorer overall sleep quality in comparison to people without binge eating. Our findings also showed binge eating can be accompanied by other sleep problems, namely hypersomnia/daytime sleepiness, insomnia, difficulty falling asleep, and that sleep problems, notably narcolepsy accompanied by cataplexy and possibly also shorter sleep duration and sleep apnea, can also be accompanied by binge eating. People undergoing treatments for eating disorders such as BED, BN, or AN of the binge/purge type and OSFED could benefit from screening tests to determine whether they may have sleep problems, and – if sleep problems exist – obtaining treatment. Some of these treatments, such as sleep hygiene education and cognitive behaviour therapy for insomnia, could be administered by up-skilled healthcare professionals treating eating disorders, enabling more comprehensive treatment.

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Author contributions

FQdL, AS and RERF were responsible for designing the review protocol. FQdL and AS were responsible for writing the report. LPG, LP conducted the search, screened potentially eligible studies, and extracted data. FQdL and RERF extracted data for the meta-analyses. ZS conducted the meta-analyses. PH, TC and CMM provided feedback on the report. All authors read and approved the final manuscript.

References

1. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed2013.

2. Kessler RC, Berglund PA, Chiu WT, Deitz AC, Hudson JI, Shahly V, et al. The Prevalence and Correlates of Binge Eating Disorder in the World Health Organization World Mental Health Surveys. Biol Psychiatry. 2013;73(9):904-14.

3. Kessler RC, Shahly V, Hudson JI, Supina D, Berglund PA, Chiu WT, et al. A comparative analysis of role attainment and impairment in binge-eating disorder and bulimia nervosa: results from the WHO World Mental Health Surveys. Epidemiol and Psychiatr Sci. 2014;23(01):27-41.

4. Javaras KN, Pope HG, Lalonde JK, Roberts JL, Nillni YI, Laird NM, et al. Co-occurrence of binge eating disorder with psychiatric and medical disorders. J Clin Psychiatry. 2008;69(2):266-73.

5. de Jonge P, Alonso J, Stein DJ, Kiejna A, Aguilar-Gaxiola S, Viana MC, et al. Associations between DSM-IV mental disorders and diabetes mellitus: a role for impulse control disorders and depression. Diabetologia. 2014;57(4):699-709.

6. Raevuori A, Suokas J, Haukka J, Gissler M, Linna M, Grainger M, et al. Highly increased risk of type 2 diabetes in patients with binge eating disorder and bulimia nervosa. Int J Eat Disord. 2015;48(6):555-62.

7. Wassenaar E, Friedman J, Mehler PS. Medical Complications of Binge Eating Disorder. Psychiatr Cli North Am. 2019;42(2):275-86.

8. da Luz FQ, Sainsbury A, Mannan H, Touyz S, Mitchison D, Hay P. Prevalence of obesity and comorbid eating disorder behaviors in South Australia from 1995 to 2015. Int J Obes. 2017;41(7):1148-53.

9. da Luz FQ, Hay P, Touyz S, Sainsbury A. Obesity with Comorbid Eating Disorders: Associated Health Risks and Treatment Approaches. Nutrients. 2018;10(7).

10. Allison KC, Spaeth A, Hopkins CM. Sleep and Eating Disorders. Curr Psychiatry Rep. 2016;18(10):1-8.

11. Blumfield ML, Bei B, Zimberg IZ, Cain SW. Dietary disinhibition mediates the relationship between poor sleep quality and body weight. Appetite. 2018;120:602-8.

12. Fatima Y, Doi SAR, Mamun AA. Sleep quality and obesity in young subjects: a meta-analysis: Sleep quality and obesity. Obes Rev. 2016;17(11):1154-66.

13. Yahia N, Brown C, Potter S, Szymanski H, Smith K, Pringle L, et al. Night eating syndrome and its association with weight status, physical activity, eating habits, smoking status, and sleep patterns among college students. Eat Weight Disord. 2017;22(3):421-33.

14. Hoon E, González-Chica DA, Vakulin A, McEvoy D, Zwar N, Grunstein R, et al. Population-based analysis of sociodemographic predictors, health-related quality of life and health service use associated with obstructive sleep apnoea and insomnia in Australia. Aust J Prim Health. 2021;27(4):304-11.

15. Lundahl A, Nelson TD. Sleep and food intake: A multisystem review of mechanisms in children and adults. J Health Psychol. 2015;20(6):794-805.

16. Fairburn C. Cognitive behavior therapy and eating disorders. New York: Guilford; 2008.

17. Allison KC, Tarves EP. Treatment of night eating syndrome. Psychiatr Clin North Am. 2011;34(4):785-96.

18. Tanahashi T, Kawai K, Tatsushima K, Saeki C, Wakabayashi K, Tamura N, et al. Purging behaviors relate to impaired subjective sleep quality in female patients with anorexia nervosa: a prospective observational study. Biopsychosoc Med. 2017;11(1):22-.

19. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. ed. Hillsdale, N.J: L. Erlbaum Associates; 1988.

20. Allison KC, Spaeth A, Hopkins CM. Sleep and Eating Disorders. Curr Psychiatry Rep. 2016;18(10):92.

21. Lauer CJ, Krieg J-C. Sleep in eating disorders. Sleep Med Rev. 2004;8(2):109-18.

22. Lombardo C, Battagliese G, Baglioni C, David M, Violani C, Riemann D. Severity of insomnia, disordered eating symptoms, and depression in female university students. Clin Psychol (Aust Psychol Soc). 2014;18(3):108-15.

23. Lombardo C, Battagliese G, Venezia C, Salvemini V. Persistence of poor sleep predicts the severity of the clinical condition after 6 months of standard treatment in patients with eating disorders. Eat Behav. 2015;18:16.

24. Tkachenko O, Olson EA, Weber M, Preer LA, Gogel H, Killgore WDS. Sleep difficulties are associated with increased symptoms of psychopathology: Sleep and the Processing of Emotional Information. Exp Brain Res. 2014;232(5):1567-74.

25. Chaput J-P, Després J-P, Bouchard C, Tremblay A. The association between sleep duration and weight gain is dependent on disinhibited eating behaviors in adults. Sleep. 2011;12:S13-S.

26. Chabas D, Foulon C, Gonzalez J, Nasr M, Lyon-Caen O, Willer J-C, et al. Eating disorder and metabolism in narcoleptic patients. Sleep. 2007;30(10):1267-73.

27. Brondel L, Romer MA, Nougues PM, Touyarou P, Davenne D. Acute partial sleep deprivation increases food intake in healthy men. Am J Clin Nutr. 2010;91(6):1550-9.

28. de Zwann M, Mitchell JE, Seim HC, Specker SM, Pyle RL, Raymond NC, et al. Eating related and general psychopathology in obese females with binge eating disorder. Int J Eat Disord. 1994;15(1):43-52.

29. Cerolini S, Ballesio A, Ferlazzo F, Lucidi F, Lombardo C. Decreased inhibitory control after partial sleep deprivation in individuals reporting binge eating: preliminary findings. PeerJ. 2020;8:e9252-e.

30. Cerolini S, Rodgers RF, Lombardo C. Partial sleep deprivation and food intake in participants reporting binge eating symptoms and emotional eating: preliminary results of a quasi-experimental study. Eat Weight Disord. 2018;23(5):561-70.

31. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193-213.

32. Alavaikko S, Jaakkola MS, Tjaderhane L, Jaakkola JJK. Asthma and Caries: A Systematic Review and Meta-Analysis. Am J Epidemiol. 2011;174(6):631-41.

33. Islam MM, Iqbal U, Walther B, Atique S, Dubey NK, Nguyen P-A, et al. Benzodiazepine Use and Risk of Dementia in the Elderly Population: A Systematic Review and Meta-Analysis. Neuroepidemiology. 2017;47(3-4):181-91.

34. Yeh S-SS, Brown RF. Disordered eating partly mediates the relationship between poor sleep quality and high body mass index. Eat Beh. 2014;15(2):291-7.

35. Fusco SdFB, Amancio SCP, Pancieri AP, Alves MVMFF, Spiri WC, Braga EM. Ansiedade, qualidade do sono e compulsão alimentar em adultos com sobrepeso ou obesidade. Rev Esc Enferm USP. 2020;54.

36. Bat-Pitault F, Da Silva C, Charvin I, Da Fonseca D. Sleep disturbances in anorexia nervosa subtypes in adolescence. Eat Weight Disord. 2021;26(6):1845-52

37. Tzischinsky O, Latzer Y, Epstein R, Tov N. Sleep-wake cycles in women with binge eating disorder. Int J Eat Disord. 2000;27(1):43-8.

38. Trace SE, Thornton LM, Runfola CD, Lichtenstein P, Pedersen NL, Bulik CM. Sleep problems are associated with binge eating in women. Int J Eat Disord. 2012;45(5):695-703.

758 39. Vardar E, Caliyurt O, Arikan E, Tuglu C. Sleep quality and psychopathological features
759 in obese binge eaters. Stress Health. 2004;20(1):35-41.
760 40. Kelly NR, Shomaker LB, Radin RM, Thompson KA, Cassidy OL, Brady S, et al.
761 Associations of sleep duration and quality with disinhibited eating behaviors in adolescent girls
762 at-risk for type 2 diabetes. Eat Behav. 2016;22:149-55.
763 41. Tzischinsky O, Latzer Y. Sleep–wake cycles in obese children with and without binge-
764 eating episodes. J Paediatr Child Health. 2006;42(11):688-93.
765 42. Tzischinsky O, Latzer Y. Sleep-wake cycles in obese adolescents with and without
766 binge eating episodes. Eur Eat Disord Rev. 2006;14(2):111-7.
767 43. Kenny TE, Van Wijk M, Singleton C, Carter JC. An examination of the relationship
768 between binge eating disorder and insomnia symptoms. Eur Eat Disord Rev. 2018;26(3):186-
769 96.
770 44. Johnson JG, Spitzer RL, Williams JBW. Health problems, impairment and illnesses
771 associated with bulimia nervosa and binge eating disorder among primary care and obstetric
772 gynaecology patients. Psychol Med. 2001;31(08):1455-66.
773 45. Reichborn-Kjennerud T, Bulik CM, Sullivan PF, Tambs K, Harris JR. Psychiatric and
774 medical symptoms in binge eating in the absence of compensatory behaviors. Obes Res.
775 2004;12(9):1445-54.
776 46. Vinai P, Cardetti S, Studt S, Carpegna G, Ferrato N, Vallauri P, et al. Clinical validity
777 of the descriptor. “Presence of a belief that one must eat in order to get to sleep” in diagnosing
778 the Night Eating Syndrome. Appetite. 2014;75:46-8.
779 47. Filipova AA, Stoffel CL. The prevalence of binge eating disorder and its relationship
780 to work and classroom productivity and activity impairment. J Am Coll Health.
781 2016;64(5):349-61.

48. Galasso L, Montaruli A, Mulè A, Castelli L, Bruno E, Caumo A, et al. The multidisciplinary therapy in binge eating disorder is able to influence the interdaily stability and sleep quality? Chronobiol Int. 2019;36(10):1311-5.

49. Roveda E, Montaruli A, Galasso L, Pesenti C, Bruno E, Pasanisi P, et al. Rest-activity circadian rhythm and sleep quality in patients with binge eating disorder. Chronobiol Int. 2017;35(2):198-207.

50. Striegel RH, Bedrosian R, Wang C, Schwartz S. Why men should be included in research on binge eating: Results from a comparison of psychosocial impairment in men and women. Int J Eat Disord. 2012;45(2):233-40.

51. Dimitrova A, Fronczek R, Van der Ploeg J, Scammell T, Gautam S, Pascual-Leone A, et al. Reward-seeking behavior in human narcolepsy. J Clin Sleep Med. 2011;7(3):293-300.

52. Fortuyn HAD, Swinkels SHN, Buitelaar JK, Renier WO, Furer JW, Rijnders CAT, et al. High prevalence of eating disorders in narcolepsy with cataplexy: a case-control study. Sleep. 2008;31(3):335-41.

53. Bulik CM, Sullivan PF, Kendler KS. Medical and psychiatric morbidity in obese women with and without binge eating. Int J Eat Disord. 2002;32(1):72-8.

54. Kim KR, Jung Y-C, Shin M-Y, Namkoong K, Kim J-K, Lee J-H. Sleep disturbance in women with eating disorder: Prevalence and clinical characteristics. Psychiatry Res. 2010;176(1):88-90.

55. Johansson AK, Johansson A, Unell L, Norring C, Carlsson GE. Eating disorders and signs and symptoms of temporomandibular disorders: a matched case-control study. Swed Dental J. 2010;34(3):139-47.

56. Ulman TF, Von Holle A, Torgersen L, Stoltenberg C, Reichborn-Kjennerud T, Bulik CM. Sleep disturbances and binge eating disorder symptoms during and after pregnancy. Sleep. 2012;35(10):1403-11.

807 57. Mason TB, Engwall A, Mead MP, Irish LA. Sleep and eating disorders among adults
808 enrolled in a commercial weight loss program: associations with self-report and objective sleep
809 measures. Eat Weight Disord. 2019;24(2):307-12.
810 58. Soares MJ, Macedo A, Bos SC, Maia B, Marques M, Pereira AT, et al. Sleep
811 disturbances, body mass index and eating behaviour in undergraduate students: Sleep
812 disturbances, body mass index and eating behaviour. J Sleep Res. 2011;20(3):479-86.
813 59. Quick V, Byrd-Bredbenner C, Shoff S, White AA, Lohse B, Horacek T, et al.
814 Relationships of Sleep Duration With Weight-Related Behaviors of U.S. College Students.
815 Behav Sleep Med. 2016;14(5):565-80.
816 60. Sockalingam S, Tehrani H, Taube-Schiff M, Van Exan J, Santiago V, Hawa R. The
817 relationship between eating psychopathology and obstructive sleep apnea in bariatric surgery
818 candidates: A retrospective study. Int J Eat Disord. 2017;50(7):801-7.
819 61. Olbrich K, Mühlhans B, Allison KC, Hahn EG, Schahin SP, de Zwaan M. Night eating,
820 binge eating and related features in patients with obstructive sleep apnea syndrome. Eur Eat
821 Disord Rev. 2009;17(2):120-7.
822 62. Erskine EH, Whiteford AH. Epidemiology of binge eating disorder. Curr Opin
823 Psychiatry. 2018;31(6):462-70.
824 63. Dahmen N, Becht J, Engel A, Thommes M, Tonn P. Prevalence of eating disorders and
825 eating attacks in narcolepsy. Neuropsychiatr Dis Treat. 2008;4(1):257-61.
826 64. Zomer J. Mini Sleep Questionnaire (mSQ) for screening large populations for EDS
827 complaints. Sleep. 1985.
828 65. Chen P-H, Kuo H-Y, Chueh K-H. Sleep hygiene education: efficacy on sleep quality
829 in working women. J Nurs Res. 2010;18(4):283-9.
830 66. Koffel EA, Koffel JB, Gehrman PR. A meta-analysis of group cognitive behavioral
831 therapy for insomnia. Sleep Med Rev. 2015;19:6-16.

67. Kendzerska TB, Smith PM, Brignardello-Petersen R, Leung RS, Tomlinson GA. Evaluation of the measurement properties of the Epworth sleepiness scale: A systematic review. Sleep Med Rev. 2014;18(4):321-31.

68. Morin CM, Belleville G, Bélanger L, Ivers H. The Insomnia Severity Index: psychometric indicators to detect insomnia cases and evaluate treatment response. Sleep. 2011;34(5):601-8.

69. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.

Table legends

Table 1. Study first author family name and publication year, aims, methodological design, sample characteristics, measures of binge eating/sleep problems, whether any relationship between binge eating and a sleep parameter was found, and whether the study was included in a meta-analysis.

Table 2. Quality assessments with adaptations of the Newcastle-Ottawa Scale and the Joanna Briggs Institute Critical Appraisal Checklist for Quasi-Experimental Studies.

Table 3. Summary effect sizes and heterogeneity from the meta-analyses conducted in this systematic review.

Figure Legends

Figure 1. Flow diagram of publication selection for the systematic review.

Figure 2. Poorer overall sleep quality in people with binge eating compared to people without binge eating.

Figure 3. Hypersomnia/daytime sleepiness in people with binge eating compared to people without binge eating.

Figure 4. Insomnia in people with binge eating compared to people without binge eating.

Figure 5. Difficulty falling asleep in people with binge eating compared to people without binge eating.

Study first author family name and publication year	Study aims	Methodological design	Sample characteristics	Measure of binge eating	Measure of sleep problems	Was any relationship between binge eating and a sleep parameter found?	Inclusion in a meta-analysis?
Bat-Pitault, 2020	-To investigate sleep characteristics, clinical profile, quality of life and emotionality in AN subtypes	- Case-control -Retrospective	- Adolescents with AN (n=111)	-Eating Disorder Inventory-2	-Pittsburg Sleep Quality Index - Epworth Sleepiness Scale adapted for children and adolescents	Yes: adolescents with AN of the binge eating/purging type had greater sleepiness and disturbances in quality, latency, and duration of sleep, as well as a preference for an evening chronotype in comparison to those with restrictive AN	Yes
Bulik, 2002	-To determine the prevalence of obesity and binge eating in a population-based sample of female twins and to examine whether the presence of binge eating was associated with a greater risk for medical and psychiatric disorders in obese women	-Cross-sectional -Population-based	- Female twins without obesity (n=1994) -Female twins with obesity (n=169)	-Question: Have you ever in your life had eating binges during which you ate a lot of food in a short period of time?	-Symptom Cheklist	Yes: the occurrence of neurovegetative symptoms – including insomnia – was greater in women with obesity and comorbid binge eating in comparison to women with obesity but without binge eating	No

Cerolini, 2018	-To evaluate the effect of partial sleep deprivation on food intake in participants reporting binge eating	-Quasi-experimental	-Adults with binge eating (n=14) -Adults without eating disorders (n=14)	-Binge Eating Scale -Disordered Eating Questionnaire -Food diary	-Insomnia Severity Index -Sleep diary -Zeo (portable electronic device)	Yes: people with binge eating had significantly higher scores on the Insomnia Severity Index in comparison to people without binge eating	Yes
Dahmen, 2008	-To evaluate the prevalence of eating disorders in narcoleptic patients compared to a control group	-Cross-sectional	-Adults with narcolepsy (n=116) -Adults without narcoleptic symptoms (n=80)	-Structured interview for anorectic and bulimic eating disorders	-Stanford Centre for Narcolepsy Sleep Inventory -Epworth Sleepiness Scale	No	No
Dimitrova, 2011	-To evaluate the decision-making and reward-seeking behaviors in participants with narcolepsy and with or without cataplexy	-Cross-sectional	-Adults with narcolepsy and cataplexy (n=30) -Adults with narcolepsy but without cataplexy (n=15) -Adults without narcolepsy or cataplexy (n=32)	-Binge Eating Scale	-Polysomnography -Multiple sleep latency test -Epworth Sleepiness Scale	Yes: people with narcolepsy accompanied by cataplexy scored significantly higher on the Binge Eating Scale in comparison to people without narcolepsy or cataplexy	Yes
Filipova, 2016	-To examine the prevalence of BED on university	-Cross-sectional	-University students (n=11,165)	-Eating Disorder	-Question: “How many hours of sleep do you	No	Yes

	campus and determine associations of BED with other health risk factors			Diagnostic Scale	usually get in a 24-hour period?"		
Fortuyn, 2008	-To assess the prevalence and symptoms of eating disorders in participants with narcolepsy	-Case-control	-Adults with narcolepsy/cataplexy (n = 60) -Adults from the general population (n = 120) -BMI-matched adults (n=32)	-Schedules for Clinical Assessment in Neuropsychiatry -One question from the Structured Clinical Interview for DSM-IV -Eating Disorders Examination-Questionnaire	-ICSD-2 diagnostic criteria of narcolepsy with cataplexy	Yes: people with narcolepsy had greater binge eating in comparison to people from a population-based sample or BMI-matched people	Yes
Fusco, 2020	-To investigate the relationship between anxiety, binge eating, and sleep quality in adults with overweight or obesity	-Cross-sectional	-Adults with overweight or obesity (n=130)	-Binge eating scale	-Pittsburgh sleep quality index	Yes: positive correlation between participants' scores on the Binge Eating Scale and on the Pittsburgh Sleep Quality Index	Yes
Galasso, 2019	-To investigate differences between participants with or without BED in interdaily stability, intradaily variability, nocturnal, and daily activity (follow-up of Roveda et al. 2017 study)	-Cross-sectional	-Female adults with BED (n=14) - Female adults without BED (n=14)	Not reported	-Actigraph (MotionWacth8®, CamNtech, Cambridge, UK)	Yes: women with BED showed better sleep quality (i.e., sleep efficiency, latency, and duration) in comparison to those without BED	Yes
Johansson, 2010	-To investigate symptoms of temporomandibular disorders in people with eating disorders	-Case-control	-Adolescents or adults with eating disorders (n=54)	-Eating disorder assessments were made by an expert team of medical	-Questionnaire with 196 questions on general and oral health	No	No

	and compare with sex- and aged-matched controls		-Sex- and age-matched people without eating disorders (n=54)	doctors, psychiatrists, and psychologists			
Johnson, 2001	-To investigate health problems and impairment associated with BN and BED among female primary care and obstetric gynaecology participants	-Cross-sectional	-Female adults (n=4651)	-Patient Health Questionnaire	-Patient Health Questionnaire	Yes: women with BN or BED reported greater insomnia in comparison to those without these eating disorders (after statistically controlling for other psychiatric disorders)	Yes
Kelly, 2016	-To evaluate the associations of sleep duration and daytime sleepiness with disinhibited eating in adolescent at-risk for type 2 diabetes	-Cross-sectional	-Female adolescents at-risk for type 2 diabetes (n=119)	-Eating Disorder Examination	-Single item on sleep duration from the Children's Sleep Habits Questionnaire -Sleep Habits Survey	Yes: daytime sleepiness was associated with a greater odd of binge eating in the previous month	Yes
Kenny, 2018	-To compare insomnia symptoms in individuals with BED and in those with no history of eating disorders	-Cross-sectional	-Adults with BED (n=68) -Adults with no history of eating disorders (n=78)	-Eating Disorder Examination 17.0	-Insomnia Severity Index	Yes: adults with BED reported significantly greater insomnia symptoms in comparison to adults without a history of eating disorders	Yes
Kim, 2010	-To assess the prevalence of sleep disturbance in participants with AN or BN	-Cross-sectional	-400 female adults/adolescents with eating disorders	-Semi-structured diagnostic interview using DSM-IV criteria	-Subjective sleep disturbance was assessed without objective validation or laboratory examination	Yes: participants with binge eating/purging behaviors had greater difficulty falling asleep and midsleep awakening in comparison to those without significant binge eating/purging behaviors	No
Mason, 2019	-To examine associations between sleep, chronotype, and eating disorder psychopathology	-Cross-sectional	-Adults enrolled in a commercial weight loss program (n=212)	-Eating Disorder Diagnostic Scale	-Composite scale of Morningness -SATED scale -Fibit Charge HR	Yes: controlling for age and BMI, adults with BN or BED were more likely to report poor sleep health and greater eveningness in comparison to adults without eating disorders	No

					-Modified version of the Pittsburgh sleep diary		
Olbrich, 2009	-To explore the association between night eating, other forms of disordered eating and obstructive sleep apnea	-Cross-sectional	-Adults with obstructive sleep apnea (n=81)	-Patient Health Questionnaire -Disorder Module of the Structured Clinical Interview for DSM-IV diagnoses	-Epworth Sleepiness Scale	Yes: this study found a 6.2% incidence of BED in a sample of 81 adults with obstructive sleep apnea prior to treatment	No
Quick, 2016	-To describe sleep behaviors, and to examine associations of sleep duration with weight-related behaviors	-Cross-sectional	- University students (n=1252)	-2-item subscale developed from the Three-Factor Eating Questionnaire Uncontrolled Eating scale	-Pittsburgh Sleep Quality Index	Yes: students that slept < 8 hours per night showed greater binge eating behaviors in comparison to those that slept > 8 hours per night	No
Reichborn-Kjennerud, 2004	-To explore the extent to which binge eating in the absence of compensatory behaviors is associated with psychiatric and medical symptoms	-Cross-sectional	-Adult twins without binge eating (n=3226) -Adult twins with binge eating (n=126)	-Questionnaire with nine questions about symptoms directly related to the DSM-IV eating disorders criteria	-Hopkins Symptom Check List - 25	Yes: binge eating was independently associated with insomnia in women (i.e., statistically controlling for BMI)	Yes
Roveda, 2017	-To assess rest-activity circadian rhythms and sleep parameters in participants with BED compared to a body mass index-matched control group	-Cross-sectional	-Female adults with BED (n=8) -BMI matched female adults (n=8)	-Assessment of BED was made by a psychiatrist using the DSM-5 criteria	-Actigraph (MotionWacth8®, CamNtech, Cambridge, UK)	No	Yes
Soares, 2011	-To examine associations between sleep	-Cross-sectional	-University students (n=870)	-Eating Attitudes Test-40	-Assessed with two items: 1) I have difficulty in	Yes: the sum of bulimic behaviour/binge eating and bulimic behaviour/purgative behaviour item	No

	difficulties, BMI and eating behavior in undergraduate students				falling asleep, and 2) I wake up many times during the night. A sleep disturbance index was calculated from the sum of the items scores	scores on the Eating Attitudes Test-40 correlated with sleep disturbances in male students	
Sockalingam, 2017	-To identify differences in BED prevalence in bariatric surgery candidates with and without obstructive sleep apnea	- Case-control - Retrospective	-Adults with obstructive sleep apnea (n=578) -Adults without obstructive sleep apnea (n=521)	-Binge Eating Scale	- Polysomnography	Yes: people with obstructive sleep apnea were more likely to have a past diagnosis of BED in comparison to those without obstructive sleep apnea	No
Striegel, 2012	-To compare demographic and clinical correlates of binge eating between men and women	-Cross-sectional	-Males with binge eating (n=1630) -Females with binge eating (n=2754) -Males without binge eating (n=20113) -Females without binge eating (n=21854)	- Binge eating was measured with four specific questions	-Sleep problem (≤6h of sleep) was assessed with the question “How many hours of sleep do you usually get in a 24-h period?”	Yes: people with binge eating reported shorter sleep duration in comparison to those without binge eating	Yes
Tanahashi, 2017	-To evaluate the relationship between sleep and purging behaviors, and to investigate associations between disordered eating behaviors and global sleep quality	-Cross-sectional	-Female adults with anorexia nervosa binge-eating/purging type (n=12) -Female adults with anorexia nervosa restricting type (n=8)	-Questions about habitual eating behaviors	-Pittsburgh Sleep Quality Index	Yes: participants with AN of the binge eating/purging type had greater circadian rhythm disruption, abnormal sleep duration, and higher global scores on the Pittsburgh Sleep Quality Index in comparison to those with restrictive AN	Yes

Trace, 2012	-To examine the association of current sleep problems, lifetime binge eating, and current obesity in women	-Cross-sectional	-Female adults (n=3,790)	-Structured Clinical Interview for DSM-IV	-Questions about current sleep habits and problems	Yes: significant associations between binge eating and sleep problems (i.e., not getting enough sleep, sleeping poorly, problems falling asleep, feeling sleepy during work or free time, and disturbed sleep), statistically controlling for obesity	Yes
Tzischinsky, 2000	-To evaluate sleep characteristics in women with obesity and BED, women with obesity without BED, and normal weight women without BED	-Cross-sectional	-Female adults with obesity and BED (n=18) - Female adults with obesity but without BED (n=13) -Normal weight female adults without BED (n=16)	Not reported	-Mini-actigraphy -Mini-sleep questionnaire -The standard technion clinical sleep questionnaire -Sleep diary	No	Yes
Tzischinsky, 2006	-To assess sleep-wake cycles among adolescents with obesity (with or without binge eating behaviors) in comparison to a normal weight control group	-Case-control	-Adolescents with obesity and binge eating (n=15) - Adolescents with obesity but without binge eating (n=17) -Normal weight adolescents (n=12)	- Structured Clinical Interview for DSM-IV	-Mini-Actigraphy -Mini-Sleep Questionnaire -The Standard Technion Clinical Sleep Questionnaire -Sleep Diary	No	Yes
Tzischinsky, 2006	-To assess binge eating episodes and to characterize sleep–wake cycles in children with obesity	-Case-control	-Children with obesity and binge eating (n=13) -Children with obesity but without binge eating (n=23)	- Structured Clinical Interview for DSM-IV	-Mini-Actigraphy -Mini-Sleep questionnaire -The Standard Technion Clinical Sleep Questionnaire -Sleep diary	Yes: children with binge eating had more difficulty falling asleep, waking up too early, mid-sleep awakening, snoring, excessive daytime sleepiness, awake time during the night, and worse sleep efficiency in comparison to children without binge eating	Yes

			-Children with normal weight (n=25)				
Ulman, 2012	-To compare sleep problems during pregnancy during and sleep dissatisfaction 18 months after pregnancy in women with or without BED	-Cohort	-Females with BED symptoms before and during pregnancy (n=1495) -Females with BED symptoms before pregnancy that remitted during pregnancy (n=921) -Females with incident BED symptoms during pregnancy (n=1235) -Females without reported eating disorder symptoms before or during pregnancy (n=68784)	-Questionnaire assessing DSM-IV eating disorders criteria	-Questionnaires from the Norwegian Mother and Child Cohort Study assessing sleep (problems, hours, and satisfaction)	Yes: This study found that participants with symptoms of BED showed greater sleep problems during the first 18 weeks of pregnancy, and more sleep dissatisfaction at 18 months after child birth, in comparison to those without eating disorder symptoms. Additionally, this study found that in the third semester of pregnancy women with incident symptoms of BED had a longer sleep duration in comparison to those without eating disorders.	No
Vardar, 2004	-To assess the prevalence of BED and to examine subjective sleep qualities and psychopathological features in participants with obesity	-Cross-sectional	-Adults with obesity and BED (n=8) -Adults with obesity but without BED (n=28) -Adults without obesity/BED (n=37)	-Clinical interview using DSM-IV criteria for BED -Bulimic Inventory Test, Edinburgh	-The Pittsburgh Sleep Quality Index	Yes: people with BED had higher global scores on the Pittsburgh Sleep Quality Index (indicating poorer sleep quality) and greater sleep latencies in comparison to people without BED	Yes

Vinai, 2014	-To investigate whether the belief that "one must eat in order to fall asleep" contributes to the onset or maintenance of night eating syndrome	-Cross-sectional	-Adults with night eating syndrome (n=8) -Adults with BED (n=33) -Adults with night eating syndrome and BED (n=13) -Adults without eating disorders (n=44)	-Eating Disorders Inventory -Clinical interview -Additional question: Do you need to eat in order to get back to sleep when you wake up at night?	-Insomnia Severity index -Sleep Disturbances Questionnaire	No	Yes
Yeh, 2014	-To evaluate the relationship between poor sleep quality and high body mass index in a community sample. And to investigate whether disordered eating partly explains this relationship	-Cross-sectional	-Adults from the general community (n=330)	-Binge Eating Scale -Night-Eating Questionnaire	-Sleep Quality Index	Yes: binge eating partly mediated the relationship between worse sleep quality and a higher BMI	Yes

Note. AN = anorexia nervosa; DSM-IV = Diagnostic and Statistical Manual of Mental Disorders Fourth Edition; ICSD-2 = International Classification of Sleep Disorders, second edition; BMI = body mass index; BED = binge eating disorder; BN = bulimia nervosa.

Newcastle-Ottawa Scale adapted for cross sectional studies								
Study	**Selection**				**Comparability**	**Outcome**		**Total score**
	Representativeness of the sample	**Sample size**	**Non-respondents**	**Ascertainment of the exposure (risk factor)**	**The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled**	**Assessment of the outcome**	**Statistical test**	
Dahmen 2008	*	---	---	**	*	*	*	6
Dimitrova 2011	*	---	---	**	**	*	*	7
Galasso 2019	*	---	---	**	**	**	*	8
Roveda 2017	*	---	---	**	**	**	*	8
Kenny 2018	*	---	---	**	**	*	*	7
Bulik 2002	*	---	---	**	*	**	*	7
Filipova 2016	*	---	---	**	**	*	*	7
Fusco 2020	*	---	---	**	*	*	*	6
Johnson 2001	*	---	---	**	**	*	*	7
Kelly 2016	*	---	---	**	**	**	*	8
Kim 2010	*	---	---	**	*	*	*	6
Mason, 2019	*	---	---	**	*	*	*	6
Olbrich, 2009	*	---	---	**	*	**	*	7
Quick, 2016	*	---	*	**	*	*	*	7
Reichborn-Kjennerud, 2004	*	---	---	*	**	*	*	6
Soares, 2011	*	---	---	**	*	*	*	6
Striegel, 2012	*	---	---	**	*	*	*	6
Tanahashi, 2017	*	---	---	**	*	*	*	6
Trace, 2012	*	---	---	**	**	*	*	7
Tzischinsky, 2000	*	---	---	**	*	**	*	7

Tzischinsky, 2006 (study with adolescents)	*	---	---	**	*	**	*	7
Tzischinsky, 2006 (study with children)	*	---	---	**	*	**	*	7
Vardar, 2004	*	---	---	**	*	**	*	7
Vinai, 2014	*	---	---	**	*	**	*	7
Yeh, 2014	*	---	---	**	**	*	*	7

Newcastle-Ottawa Scale adapted for case-control studies

Study	**Selection**				**Comparability**	**Exposure**			**Total Score**
	Is the case definition adequate?	**Representativeness of cases**	**Selection of controls**	**Definition of controls**	**Comparability of cases and controls on the basis of the design or analysis**	**Ascertainment of exposure**	**Same method of ascertainment for cases and controls**	**Non-response rate**	
Bat-Pitault 2020	*	*	---	*	*	*	*	---	6
Fortuyin 2008	*	*	*	*	*	*	*	---	7
Johansson 2010	*	*	---	*	*	*	*	---	6
Sockalingam 2017	*	*	---	*	*	*	*	---	6

Newcastle-Ottawa Scale adapted for cohort studies

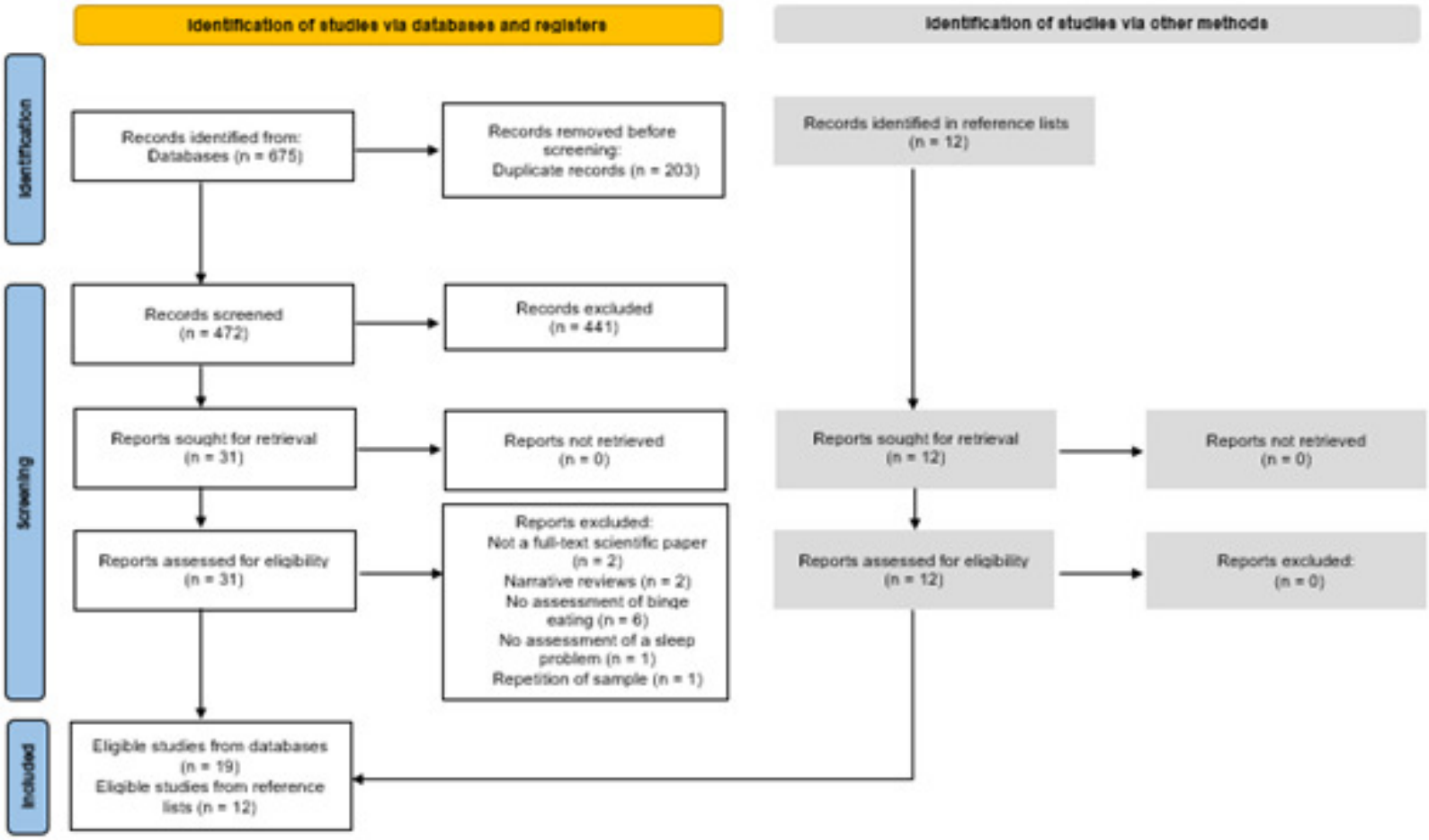
Study	**Selection**				**Comparability**	**Outcome**			**Total Score**
	Representativeness of the exposed cohort	**Selection of the non-exposed cohort**	**Ascertainment of exposure**	**Demonstration that outcome of interest was not present at start of study**	**Comparability of cohorts on the basis of the design or analysis**	**Assessment of outcome**	**Was follow-up long enough for outcomes to occur**	**Adequacy of follow up of cohorts**	
Ulman, 2012	*	*	*	*	**	*	*	*	9

Joanna Briggs Institute Critical Appraisal Checklist for Quasi-Experimental Studies									
Study	**Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?**	**Were the participants included in any comparisons similar?**	**Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?**	**Was there a control group?**	**Were there multiple measurements of the outcome both pre and post the intervention/exposure?**	**Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?**	**Were the outcomes of participants included in any comparisons measured in the same way?**	**Were outcomes measured in a reliable way?**	**Was appropriate statistical analysis used?**
Cerolini 2018	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Yes	Yes

Category	**Nº of studies**	**Summary effect**			**Heterogeneity**				
		Type [a]	**Size (95% confidence interval)**	***P* value** [a]	**Q (degrees of freedom)**	***P* value for X^2 test on Q** [b]	I^2 **(%)** [c]	***Tau*** [d]	**Prediction Interval**
Poor overall sleep quality	7	SMD	0.77 (0.61 to 0.92)	**<0.001**	4.81 (6)	0.568	0.0	0.000	0.61 to 0.92
Hypersomnia/ daytime sleepiness	7	SMD	0.57 (0.20 to 0.94)	**0.002**	13.46 (6)	**0.036** (heterogenous)	55.4	0.362	-0.47 to 1.62
Insomnia	5	SMD	0.66 (0.36 to 0.95)	**<0.001**	34.23 (6)	**<0.001** (heterogenous)	82.5	0.340	-0.30 to 1.61
Difficulty falling asleep	3	SMD	0.62 (0.31 to 0.94)	**<0.001**	2.17 (2)	0.338	7.8	0.085	-1.68 to 2.92 [e]
Difficulty staying asleep	3	DIM (score)	0.52 (-0.09 to 1.13)	0.097	1.07 (2)	0.585	0.0	0.000	-0.09 to 1.13
Problems waking up too early	3	SMD	0.23 (-0.28 to 0.74)	0.375	4.30 (2)	0.117	53.5	0.332	-5.14 to 5.60
Snoring	3	DIM (score)	0.69 (-0.19 to 1.57)	0.126	2.35 (2)	0.308	15.0	0.303	-6.21 to 7.59
Sleep duration	11	SMD	0.06 (-0.10 to 0.24)	0.452	258.07 (11)	**<0.001** (heterogenous)	95.7	0.201	-0.43 to 0.56
Sleep efficiency	7	SMD	0.11 (-0.37 to 0.60)	0.649	20.04 (6)	**<0.001** (heterogenous)	70.1	0.535	-1.40 to 1.63
Sleep latency	6	DIM (minutes)	-1.86 (-6.50 to 2.77)	0.430	7993.30 (5)	**<0.001** (heterogenous)	99.9	4.865	-16.88 to 13.15

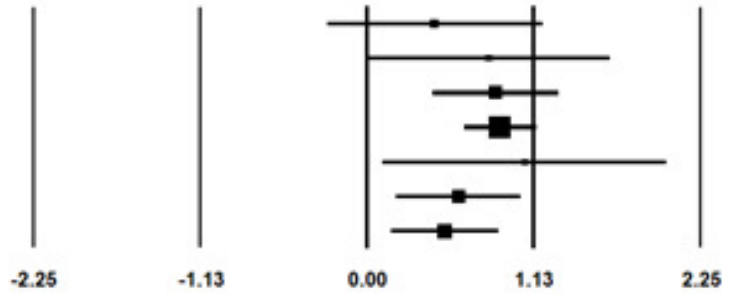
Wake time after sleep onset	3	DIM (minutes)	10.74 (-26.67 to 48.14)	0.574	15.25 (2)	**<0.001** (heterogenous)	86.9	29.796	-438.85 to 460.32
Binge eating in narcolepsy accompanied by cataplexy	2	SMD	0.55 (0.20 to 0.91)	**0.002**	0.08 (1)	0.782	0.0	0.000	Not enough studies to be relevant

Abbreviations: SMD = standardized mean difference; DIM = difference in means. [a] The probability (*P* value) of observing the calculated summary effect size shown at left if the null hypothesis were true (i.e., if there were no difference between the two comparator groups). *P* values of less than 0.05 (bolded) indicate a statistically significant difference between groups. [b] The probability (*P* value) of observing the calculated value of Q at left if the null hypothesis were true (i.e., if all studies included in the meta-analysis had the same underlying or true effect size). *P* values of less than 0.05 (bolded) indicate that the underlying or true effect sizes are variable, albeit a significant *P* value does not tell us how much variability there is. [c] Indicates what proportion of the observed variation in effect sizes between studies is due to variability in the underlying or true effect sizes (i.e., what proportion of the observed variability between studies would remain if variability due to sampling error were removed). [d] The standard deviation of (i.e., the degree of variability in) the underlying or true effect sizes. [e] While the high *P* value (of 0.338) for the X^2 test on Q suggests homogeneity in the underlying or true effect sizes, and the low value of *Tau* relative to the summary effect size (i.e., 0.085 relative to 0.62) indicates low variability in the underlying or true effect sizes, these values combined with the low value of I^2 (i.e., 7.8%) indicates high variability in the underlying effect sizes, as shown by the wide prediction interval.


Identification of studies via databases and registers
Identification of studies via other methods
Identification
Screening
Included
Records identified from:
Databases (n = 675)
Records removed before screening:
Duplicate records (n = 203)
Records identified in reference lists (n = 12)
Records screened (n = 472)
Records excluded (n = 441)
Reports sought for retrieval (n = 31)
Reports not retrieved (n = 0)
Reports sought for retrieval (n = 12)
Reports not retrieved (n = 0)
Reports assessed for eligibility (n = 31)
Reports excluded:
Not a full-text scientific paper (n = 2)
Narrative reviews (n = 2)
No assessment of binge eating (n = 6)
No assessment of a sleep problem (n = 1)
Repetition of sample (n = 1)
Reports assessed for eligibility (n = 12)
Reports excluded: (n = 0)
Eligible studies from databases (n = 19)
Eligible studies from reference lists (n = 12)

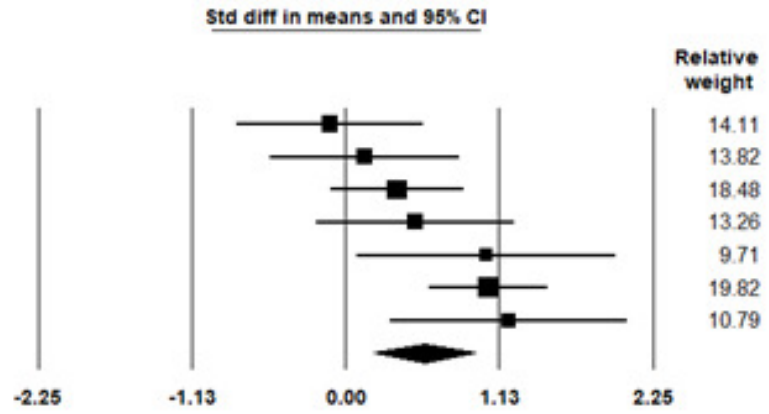
Total sleep quality

First author and year	Std diff in means	Lower limit	Upper limit	p-Value	Relative weight
Tzischinsky 2000	0.45	-0.27	1.18	0.22	4.62
Vardar 2004	0.82	0.02	1.63	0.05	3.69
Trace 2012	0.87	0.45	1.29	0.00	13.70
Yeh, 2014	0.90	0.66	1.14	0.00	42.68
Tanahashi 2017	1.06	0.11	2.02	0.03	2.65
Bat-Pitault 2020	0.62	0.20	1.03	0.00	14.00
Fusco 2020	0.52	0.16	0.88	0.00	18.66

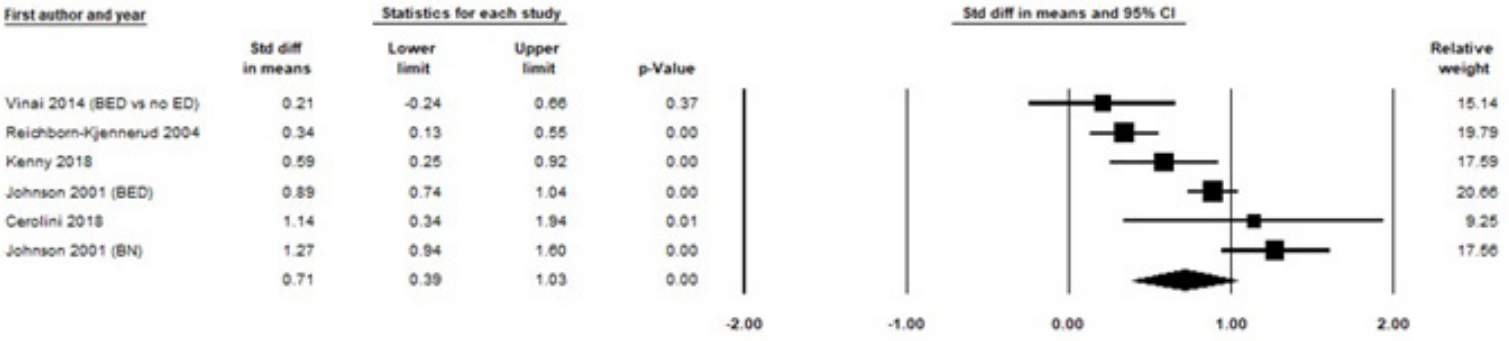


Hypersomnia/daytime sleepness

First author and year	Std diff in means	Lower limit	Upper limit	p-Value	Relative weight
Tzischinsky 2006	-0.12	-0.80	0.56	0.73	14.11
Tzischinsky, Latzer 2006	0.14	-0.56	0.83	0.70	13.82
Trace 2012	0.37	-0.11	0.86	0.13	18.48
Tzischinsky 2000	0.51	-0.21	1.24	0.17	13.26
Tanahashi 2017	1.02	0.08	1.97	0.03	9.71
Bat-Pitault 2020	1.04	0.61	1.47	0.00	19.82
Kelly 2016	1.19	0.32	2.06	0.01	10.79
	0.57	0.20	0.94	0.00	



Insomnia


First author and year
Statistics for each study
Std diff in means and 95% CI
Std diff in means
Lower limit
Upper limit
p-Value
Relative weight
Vinai 2014 (BED vs no ED) 0.21 -0.24 0.66 0.37 15.14
Reichborn-Kjennerud 2004 0.34 0.13 0.55 0.00 19.79
Kenny 2018 0.59 0.25 0.92 0.00 17.59
Johnson 2001 (BED) 0.89 0.74 1.04 0.00 20.66
Cerolini 2018 1.14 0.34 1.94 0.01 9.25
Johnson 2001 (BN) 1.27 0.94 1.60 0.00 17.56
0.71 0.39 1.03 0.00
-2.00
-1.00
0.00
1.00
2.00

Difficulty falling asleep

First author and year	Std diff in means	Lower limit	Upper limit	p-Value	Relative weight
Tzischinsky 2006	0.21	-0.49	0.90	0.56	19.36
Tzischinsky, Latzer 2006	0.53	-0.16	1.22	0.13	19.64
Trace 2012	0.78	0.41	1.15	0.00	61.00
	0.62	0.31	0.94	0.00