Approaches to Measuring and Conceptualising Sleep Discrepancy: A Scoping Review

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1 Abstract

1.1 Study Objectives

To examine how past studies have conceptualised sleep discrepancy and identify and evaluate the methods used.

1.2 Method

We searched MEDLINE, Embase, PsycINFO, CINAHL Plus, PubMed, Scopus, and Web of Science in April 2022 for studies comparing self-report and objective measures of sleep. Methodological information was extracted from relevant studies and included measures of self-report and objective sleep, sleep variables (e.g., total sleep time), derived discrepancy indices (e.g., difference scores), handling of repeated measurements, and methods of measure comparison (e.g., Bland-Altman analyses).

1.3 Results

Two hundred and forty-four relevant records were identified. Studies varied according to objective sleep measure; actigraphy algorithm, software, and rest interval; polysomnography setting and scoring criteria; sleep variables; self-report sleep measure; number of nights of objective recording; time frame of self-report measure; self-report sleep variable definition; sleep discrepancy derived index; presence and handling of repeated measurements; and statistical method for measure comparison.

1.4 Conclusions

Sleep discrepancy was mostly conceived as discordance in sleep states or sleep time variables, and various forms of this discordance differed in their conceptual distance to sleep misperception. Furthermore, studies varied considerably in methodology with critical conceptual and practical implications that have received little attention to date. Substantive methodological issues were also identified relating to the use of derived indices for operationalising sleep discrepancy, defining objective sleep onset latency, calculating actigraphy rest intervals, measuring correlation and concordance, averaging sleep variables across nights, and defining sleep quality discrepancy.

1.5 Key words

Sleep discrepancy; sleep misperception; scoping review

1.6 Statement of Significance

Sleep discrepancy, the discordance between self-report and objective measures of sleep, is an important feature for theory in insomnia and a key issue in sleep measurement. Despite the considerable research in this area, the status of sleep discrepancy as a concept is unclear and varied methodologies are employed with unknown theoretical or conceptual implications. This scoping review integrates a comprehensive range of methodological details from sleep discrepancy studies, clarifying the concept of sleep discrepancy and critically evaluating approaches to its measurement. The broad view of the literature afforded by the systematic search allows us to identify and discuss conceptual and methodological issues that have received little attention and are critical for the advancement of research in sleep discrepancy.

2 Introduction

Sleep is measured in two principal ways: objectively through polysomnography or actigraphy, and by self-report through questionnaires or sleep diaries. The discordance that can exist between these two forms of measurement is known as subjective-objective sleep discrepancy, or more simply, sleep discrepancy. Sleep discrepancy is a common feature of insomnia disorder, where it is also referred to as sleep misperception or paradoxical insomnia. Individuals with insomnia tend to underestimate total sleep time (TST), and overestimate sleep onset latency (SOL) and wake after sleep onset (WASO) relative to objective measures1–3.

There are diverse ways to conceptualise and measure sleep discrepancy. It may be considered as a spectrum4, ranging from positive (self-report exceeds objective) to negative (objective exceeds self-report), or as a measure of absolute sleep agreement5. Any number of sleep variables such as TST, SOL, or WASO can used to operationalise sleep discrepancy, each differing conceptually and carrying varying theoretical implications. Sleep discrepancy may even be considered beyond these sleep time-based metrics and represent discordance in self-report and objective sleep patterns6, or sleep quality. Sleep discrepancy can be characterised in a sample by directly comparing self-report and objective sleep with a range of statistical techniques. Other studies may derive variables to define sleep discrepancy quantitatively to measure its relationship with other variables, for example using a difference score of self-report TST – objective TST.

To date, there have been few systematic attempts to synthesise or evaluate the varied approaches to investigating sleep discrepancy. Three reviews have been conducted in this area. Castelnovo et al7 conducted a systematic review of quantitative definitions of paradoxical insomnia, an insomnia subvariant defined, in part, by the presence of sleep discrepancy. This excluded studies where sleep discrepancy was not used to form diagnostic criteria. Two subsequent reviews were conducted by Rezaie et al8 and Stephan et al9 focussing on paradoxical insomnia and the correlates of sleep misperception, respectively. Whilst informative discussions of research findings, these studies excluded a focus on concepts or methodology and did not incorporate a systematic search—potentially underrepresenting the breadth of the literature.

Presently, it is not clear how sleep discrepancy should best be defined and the diversity in its measurement and conceptualisation may present a challenge to theory-building for research in insomnia and other areas. A scoping review is a method of research synthesis that aims to map existing literature in a field of interest and identify types of evidence available in a given topic10. We used a scoping review strategy to examine how sleep discrepancy has been conceptualised in the literature and identify and evaluate the methods used to investigate it. A preliminary search of MEDLINE (Ovid), the Cochrane Library, Embase (Ovid), and PsycINFO (Ovid) was conducted to identify existing or in-progress systematic or scoping reviews on the topic. Except for the two reviews mentioned above, no records were identified.

3 Methods

3.1 Protocol and registration

The review was conducted according to guidelines provided by the JBI scoping review methodology group11 and reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist12. A review protocol was registered with the Open Science Framework on April 4, 2022 (doi: 10.17605/OSF.IO/BCJNQ), prior to conducting searches. Deviations from the protocol are outlined in the appendices ([11.2](http://127.0.0.1:10065/rmd_output/0/#deviations)).

3.2 Eligibility criteria

Participants of all age groups and clinical populations were included in the review. To adequately map the boundaries of sleep discrepancy as a concept, we included any study that compared an objective measure of sleep (e.g., polysomnography, actigraphy) with an equivalent self-report measure of sleep (e.g., sleep diaries, questionnaires), through statistical analysis or composite index scores. For measures of self-report and objective sleep, we included traditional indices of sleep time such as TST, SOL, and WASO, in addition to measures of sleep quality, sleep patterns, or any other sleep-related experience or behaviour.

3.3 Exclusion criteria

Studies were excluded that (i) made no direct comparisons between equivalent self-report and objective sleep measures, (ii) included informant, rather than self-report measures, (iii) were case reports or review articles, (iv) were limited to self-report or objective measures not related to sleep, (v) contained no empirical data, (vi) omitted either a self-report or equivalent objective measure of sleep, or (vii) were a grey literature source including theses, dissertations, and conference abstracts. No records were excluded on the basis of geographic location, cultural factors, or any other contextual feature.

3.4 Search strategy

The search strategy aimed to identify articles published in peer-reviewed journals and, initially, grey literature including theses, dissertations, and conference abstracts. Due to the large number of records returned by initial searches, grey literature was excluded at the full text extraction stage. The following databases were searched: MEDLINE (Ovid), Embase (Ovid), PsycINFO (Ovid), CINAHL Plus, PubMed, Scopus, Web of Science, ProQuest Theses and Dissertations, and OSF Preprints. The search strategy included keywords, index terms, and search operators adapted for each database. Searches across all databases were conducted on the 24th April 2022. The full search strategy for Embase (Ovid) is provided as an example in Table [3.1](http://127.0.0.1:10065/rmd_output/0/#tab:egsearch) below. See Appendix A for full search strategies for other databases.

| Table 3.1: Search strategy for Embase (Ovid) | | |
| --- | --- | --- |
| **Step** | **Terms and Operators** | **Records** |
| 1 | sleep discrepancy or paradoxical insomnia or subjective insomnia or (sleep adj2 misperception).mp | 488 |
| 2 | ((self report\* or diary or subjective*) and (objective* or actigraph\* or polysomnograph\* or polygraph\*)).mp. | 193243 |
| 3 | (exp polysomnography/ or exp actimetry/) and exp self report/ | 1676 |
| 4 | (sleep\* and (“over estimat*” or ”over report*” or “under estimat*” or ”under report*” or overestimat\* or overreport\* or underestimat\* or underreport\* or discrepan\* or concordan\* or agreement or disagreement or discordan\* or congruen\* or incongruen\*)).mp. | 9362 |
| 5 | 2 or 3 | 193302 |
| 6 | 4 and 5 | 1234 |
| 7 | 1 or 6 | 1569 |

3.5 Sources of evidence selection

Records identified from searches were exported to EndNote 2013 for collation and then uploaded to Rayyan14 for deduplication and title and abstract screening. Two independent reviewers (TW and SF) screened titles and abstracts to identify studies for full-text retrieval using the inclusion criteria. Percentage of agreement between reviewers was 87.6% and conflicts were resolved via discussion. The full-texts of articles passing title and abstract screening were screened independently by TW with reasons for exclusion reported. Due to the unanticipated size of the literature, articles from sources other than peer-reviewed journals were added to exclusion criteria post-hoc.

3.6 Charting the data

Data extraction was performed by TW, independently. Methodological features of included articles were selected on their potential influence on the measurement or operational definition of sleep discrepancy and included the following: objective sleep measure type/hardware, actigraphy algorithm, software, and rest interval, polysomnography setting and scoring criteria, self-report sleep measure, sleep variables (e.g., TST, WASO etc…) and definitions thereof, methods of handling repeated measurements, methods of comparing self-report and objective sleep within groups, and methods for operationalising sleep discrepancy to investigate its relationship with other variables.

3.7 Data items

Extracted data items numbered in the hundreds and are described comprehensively in the codebook available at <https://github.com/tfwalton/sleep-discrepancy-review/raw/main/codebook.xlsx>.

3.8 Synthesis of results

This manuscript, including all tables and figures summarising data were generated using computationally reproducible methods15,16 in R version 4.3.217, with R Studio18 and R Markdown19. Packages used in the code for this manuscript include tidyverse20, bookdown21, knitr22, kableExtra23, english24, and DiagrammeR25. All code and data are available through the Github repository: <https://github.com/tfwalton/sleep-discrepancy-review>.

4 Results

The initial search of databases returned 6,190 from which 3,903 duplicate articles were removed. Details of the review process from article identification, screening, and selection are available in the PRISMA flowchart depicted in [4.1](http://127.0.0.1:10065/rmd_output/0/#fig:PRISMA) below.

A flowchart of a flowchart

Description automatically generated

Figure 4.1: PRISMA flowchart

4.1 Article characteristics

A total of 248 studies were identified from 244 records, with 4 records reporting two studies or experiments within a single text. Records spanned 32 countries, with the majority originating from the USA (n = 96).

Sample sizes for studies ranged from 8 to 8,438 (median = 66, IQR = 119.5). Most studies included both sexes in their samples (n = 229), whereas 8 and 11 comprised only males or females, respectively. Most studies contained samples of adults of all ages (n = 197). Others reported specific age groups: older adults (n = 23), younger adults (n = 14), adolescents (n = 8), and children (n = 6). Sample characteristics for studies are included in Figure [4.2](http://127.0.0.1:10065/rmd_output/0/#fig:samplechar). For a full list of article characteristics, see the appendices ([11.4](http://127.0.0.1:10065/rmd_output/0/#tab:studychar))

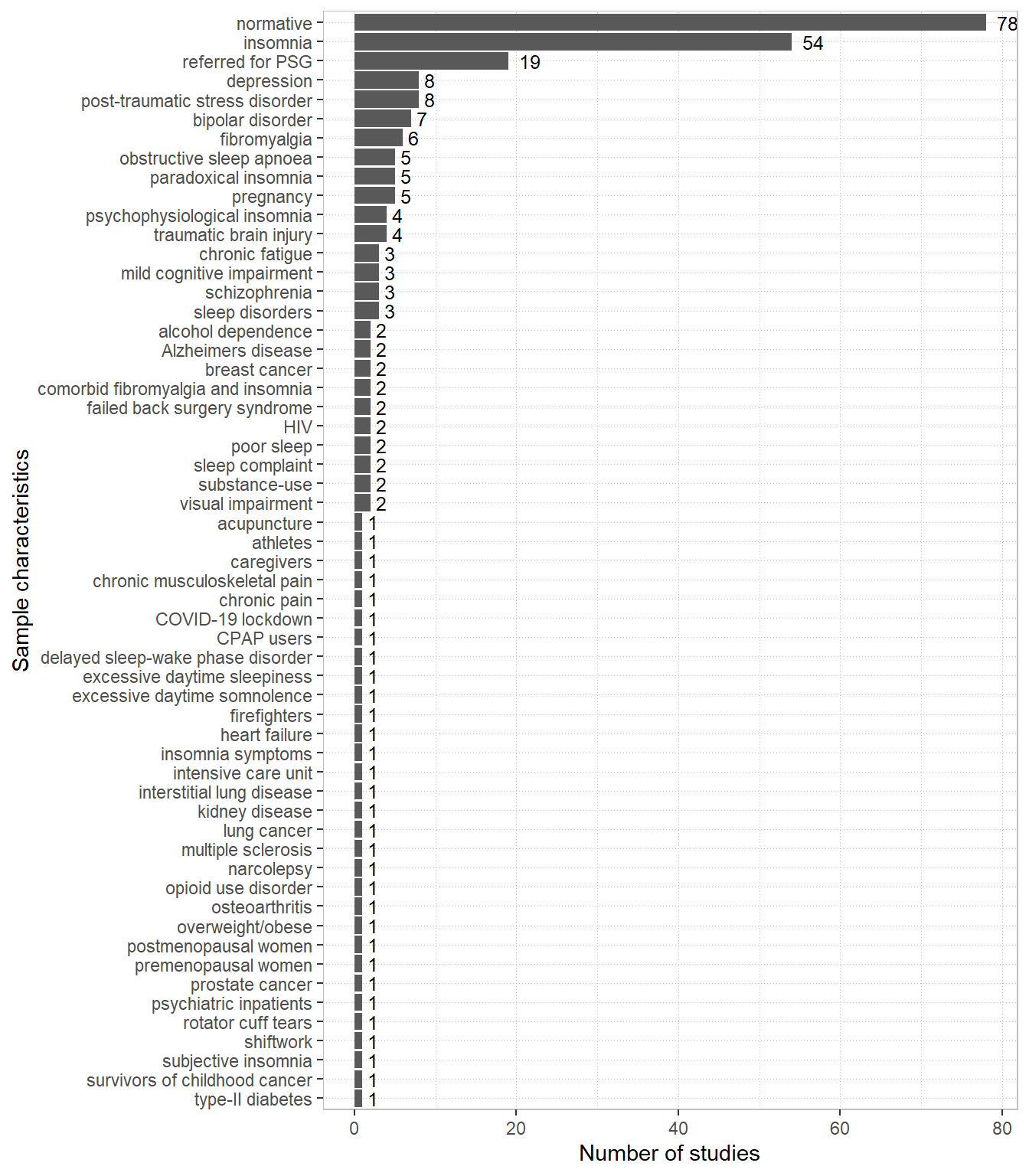


Figure 4.2: Sample characteristics

4.2 Methodological features

4.2.1 Measures of objective sleep

Objective methods of recording sleep formed two major groups: EEG-based methods and movement-based methods. See Figure [4.3](http://127.0.0.1:10065/rmd_output/0/#fig:measures) for number of studies using each method. All movement-based methods involved tri-axial accelerometry through actigraphs or similar devices. PSG was the predominant EEG-based method (n = 106), however a handful of studies used EEG alone, in either single channel (n = 2), standard (n = 4), or high-definition formats (n = 3). A single study used a method of sleep recording that involved recording verbal responses from participants elicited by soft tones played at intervals throughout the night26.

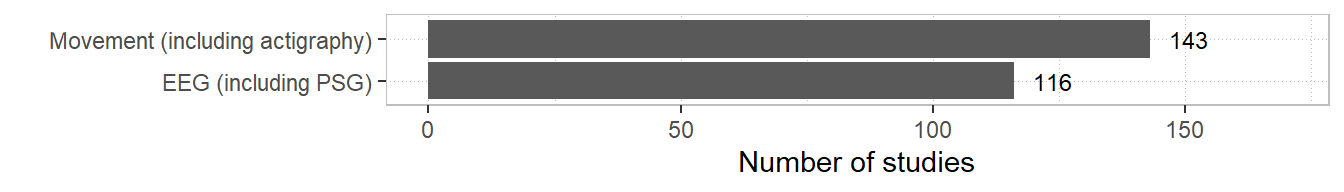


Figure 4.3: Measures of objective sleep

4.2.1.1 Polysomnography

Methodological features charted for PSG included scoring criteria, setting, and recording period. See Figure [4.4](http://127.0.0.1:10065/rmd_output/0/#fig:scoring) for scoring criteria of included studies.

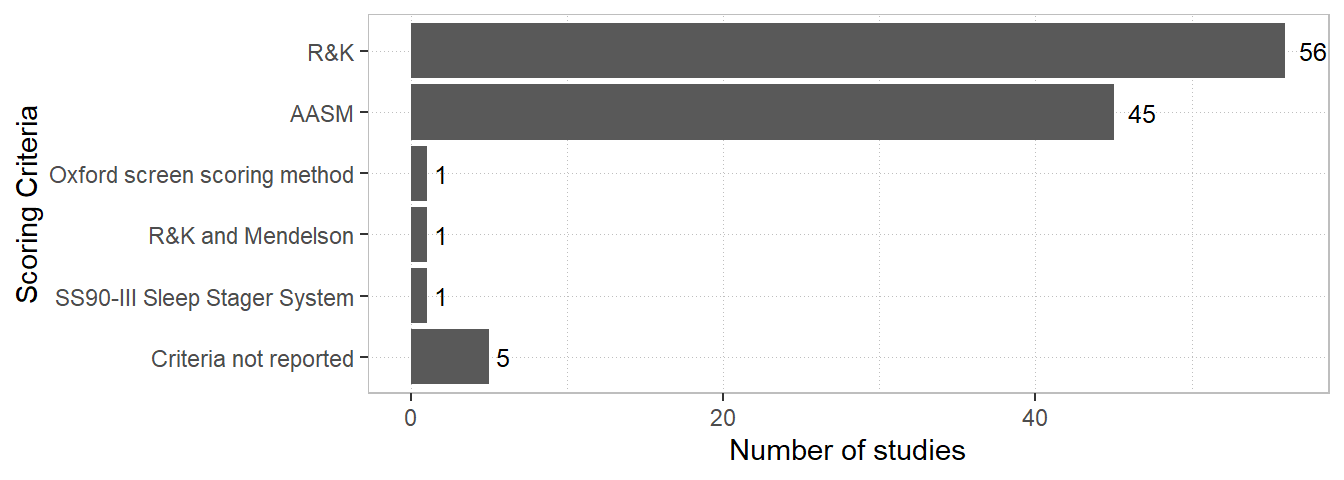


Figure 4.4: PSG scoring methods

Methods for scoring PSG were mostly divided between American Academy of Sleep Medicine (AASM) and Rechtschaffen & Kales (R&K) guidelines. Rogers et al27 used an automated system for sleep staging, the SS90-III Sleep Stager System (Oxford Medicals, Oxford). Vanable et al28 used Mendelson’s29 guidelines in addition to R&K. Edinger2 used combined audio and visual criteria for sleep staging30. Settings for PSG varied and are depicted in Figure [4.5](http://127.0.0.1:10065/rmd_output/0/#fig:setting).

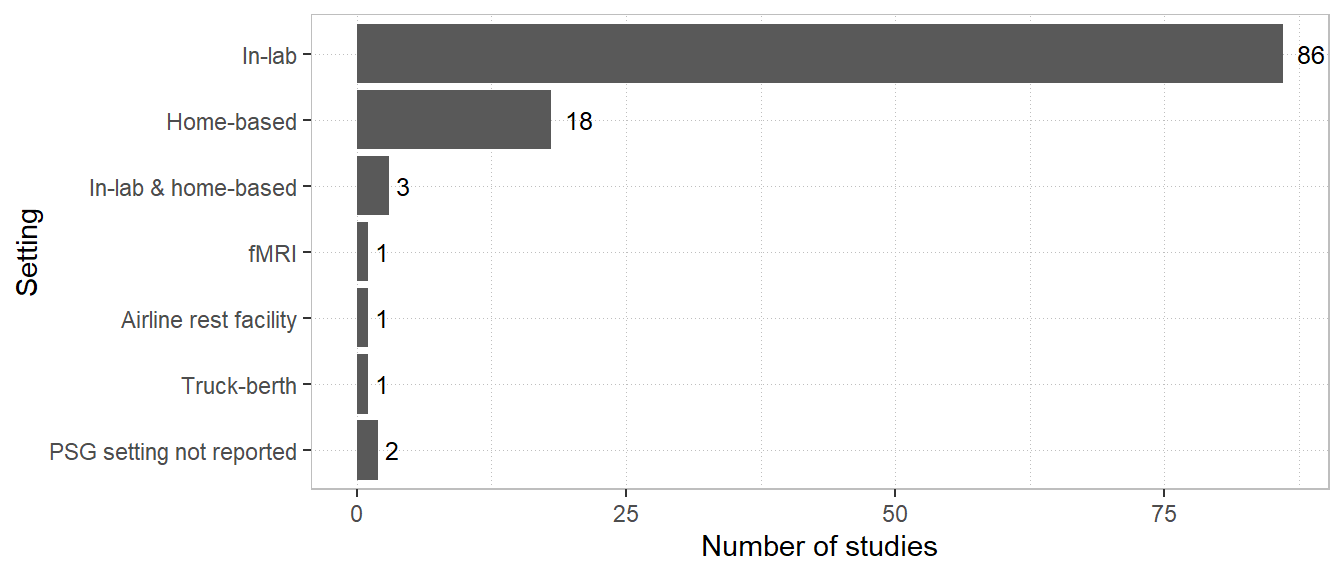


Figure 4.5: PSG setting

In-lab and home-based tests comprised the substantial majority of PSG settings with a handful of more unusual settings noted. As for recording periods, PSG most often occurred during the night although a number of alternative periods were noted. See Figure [4.6](http://127.0.0.1:10065/rmd_output/0/#fig:period) for a depiction of PSG recording periods.

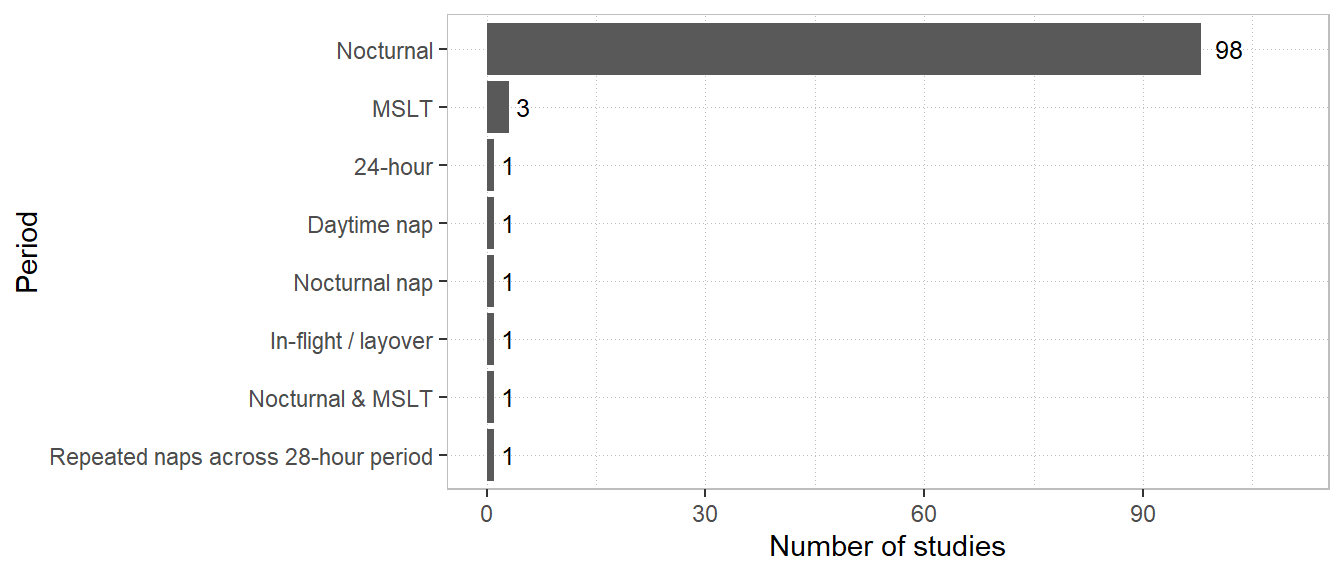


Figure 4.6: PSG recording period

Note, MSLT refers to the multiple sleep latency test.

4.2.1.2 Actigraphy

We recorded features of actigraphy including device name, scoring algorithm, software, and rest interval definition. See Table [11.5](http://127.0.0.1:10065/rmd_output/0/#tab:bigacti) in the appendices for full tabulations of actigraphy characteristics. Actigraphy scoring algorithms are responsible for determining wakefulness and sleep from accelerometer-derived motor activity. Scoring algorithms varied across studies and included Actiware31, MotionWare (CamNTech, UK), SenseWear32, Domino Light33, Cole-Kripke34, Kripke35, Sadeh36, Actiheart37, Fitbit38, UCSD38, ActiLife39, Actillume38, Micro-Electro-Mechanical-Systems40, Sleep Sign Act (Kissei Comtec Co, Japan), IM Systems (Individual Monitoring Systems, Inc., UWA), Machine Learning Alogrithms41, Fatigue Science42, Barouni43, Choi44, Tudor-Locke45, and Troiano46. The frequencies of these algorithms are depicted in Figure [4.7](http://127.0.0.1:10065/rmd_output/0/#fig:algorithms).

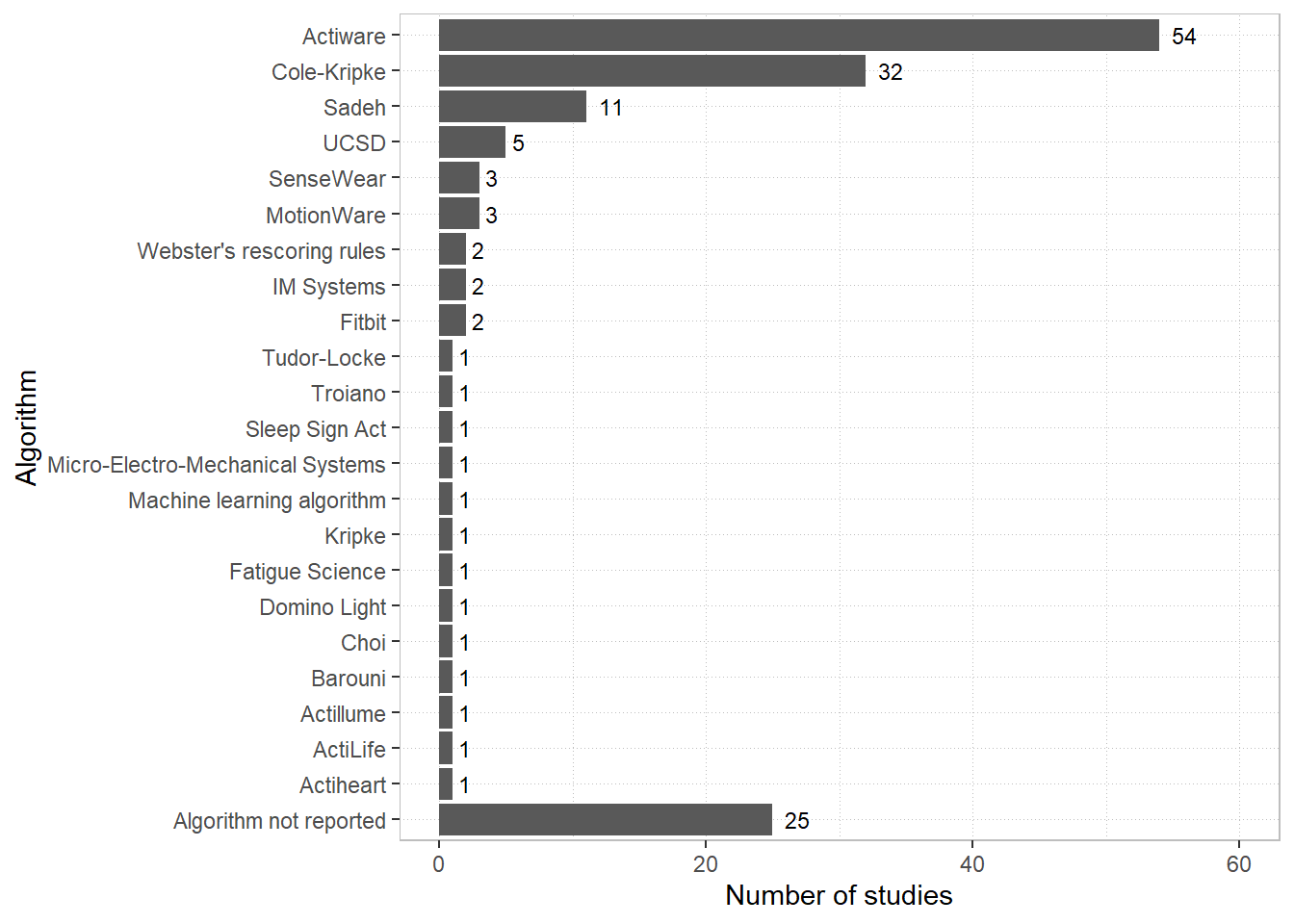


Figure 4.7: Actigraphy algorithms

Studies using Actiware algorithms varied in their selection of thresholds for scoring wakefulness. These are depicted in Figure [4.8](http://127.0.0.1:10065/rmd_output/0/#fig:actiware) below.

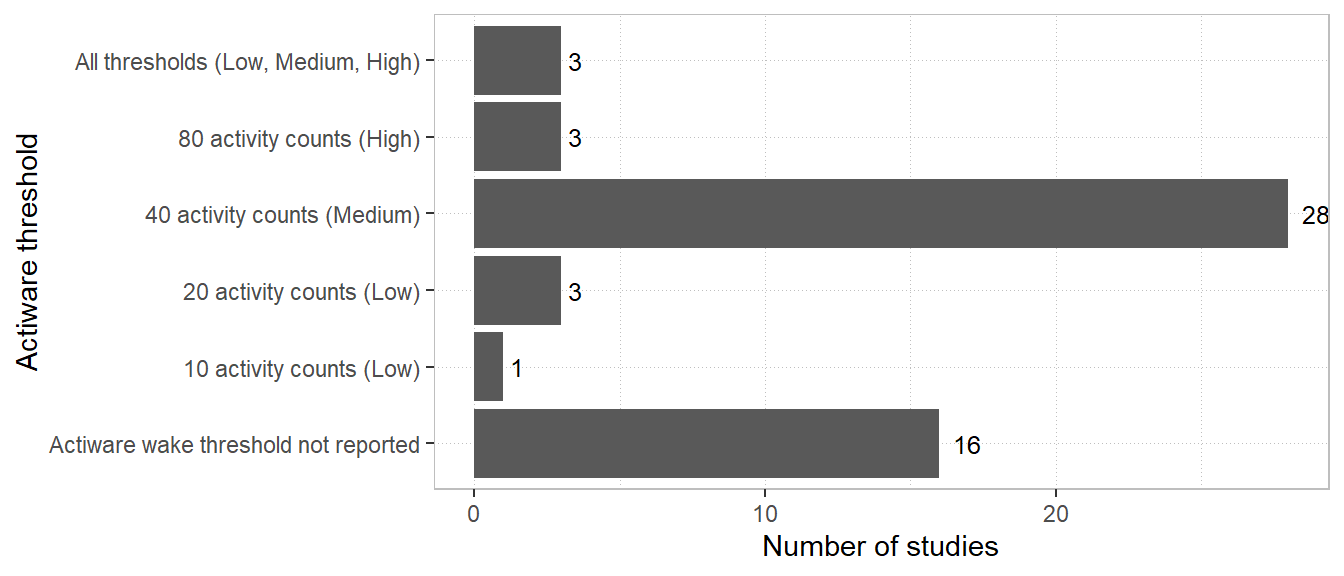


Figure 4.8: Actiware algorithm threshold settings

The rest interval in actigraphy is the period of time where activity is assessed for sleep and is usually intended to coincide with the time the wearer is in bed, attempting to sleep. Information used to define rest intervals varied across reviewed studies and included, singly or in combination, are depicted below in Figure [4.9](http://127.0.0.1:10065/rmd_output/0/#fig:intervals).

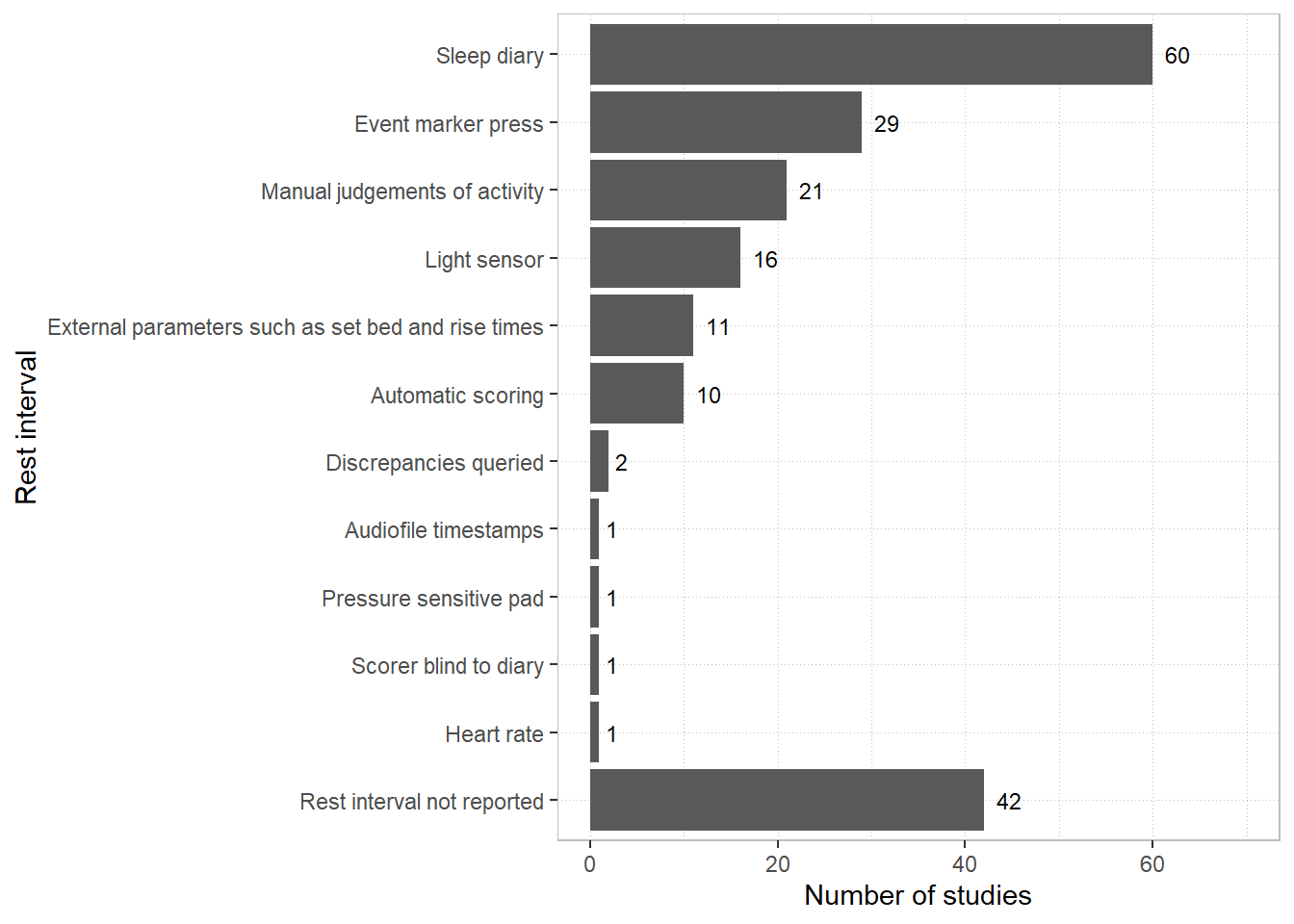


Figure 4.9: Methods for defining rest intervals in actigraphy

The precise combination and order of priority of methods in each study varied markedly. See Table [11.5](http://127.0.0.1:10065/rmd_output/0/#tab:bigacti) in the appendices for qualitative descriptions of rest interval approaches across reviewed studies. “Discrepancies queried” indicates that discrepant sleep diary and actigraphy bed and wake times were queried directly with participants and adjusted following discussion.

4.2.2 Measures of self-report sleep

Self-report sleep measures comprised seven major types. See Figure [4.10](http://127.0.0.1:10065/rmd_output/0/#fig:srmeasure) for the number of studies including each of these.

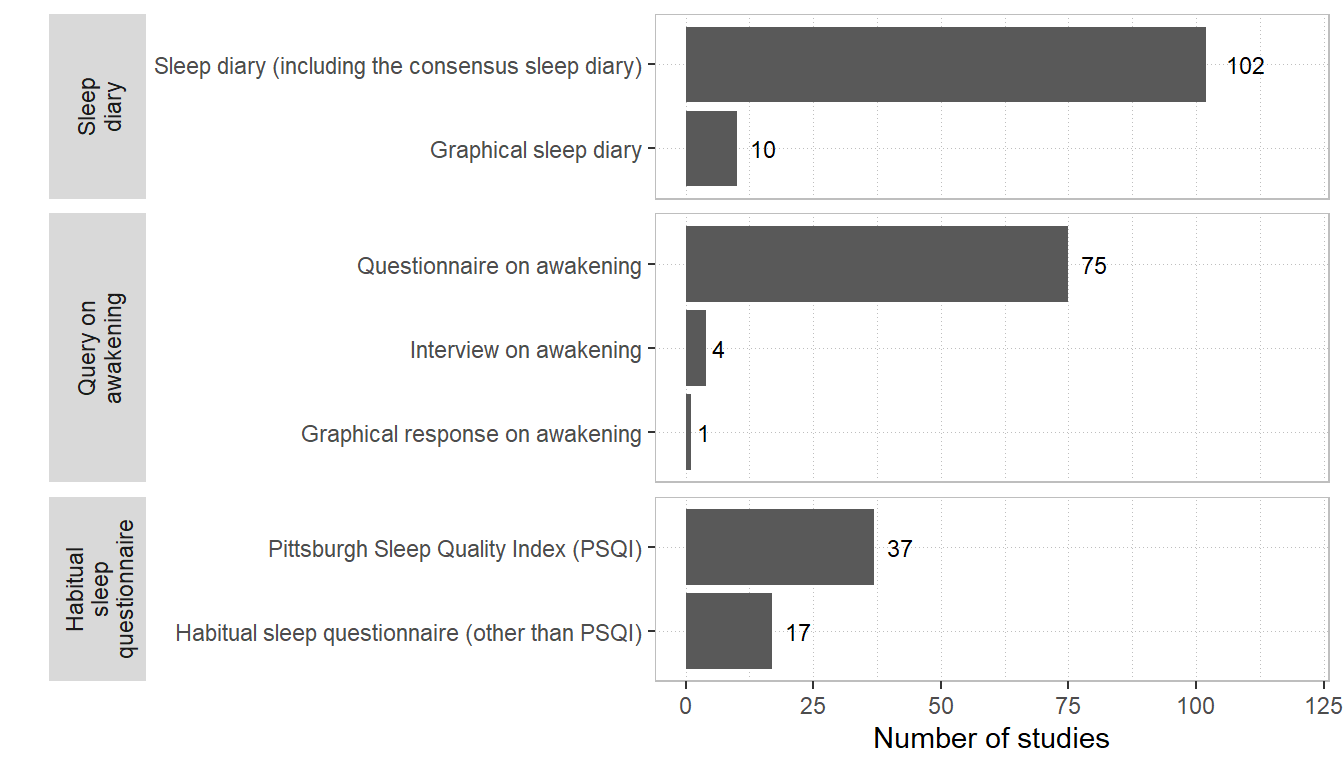


Figure 4.10: Measures of self-report sleep

Sleep diaries and questionnaires on awakening were the most common measure of self-report sleep, followed by habitual sleep questionnaires including the Pittsburgh Sleep Quality Index (PSQI)47. Note, habitual sleep refers to questionnaires that require participants to provide global judgements about their sleep that correspond to a period of time longer than a single night such as a week or a month. Graphical response formats for sleep diaries and questionnaires on awakening required participants to draw their sleep on scales comprising discrete blocks of time. We also recorded whether self-report measures overall attempted to capture habitual sleep or rather *episodic* sleep that occurred night-by-night/episode-by-sleep episode at the same time as objective measures. Results are depicted in Figure [4.11](http://127.0.0.1:10065/rmd_output/0/#fig:habitual) below.

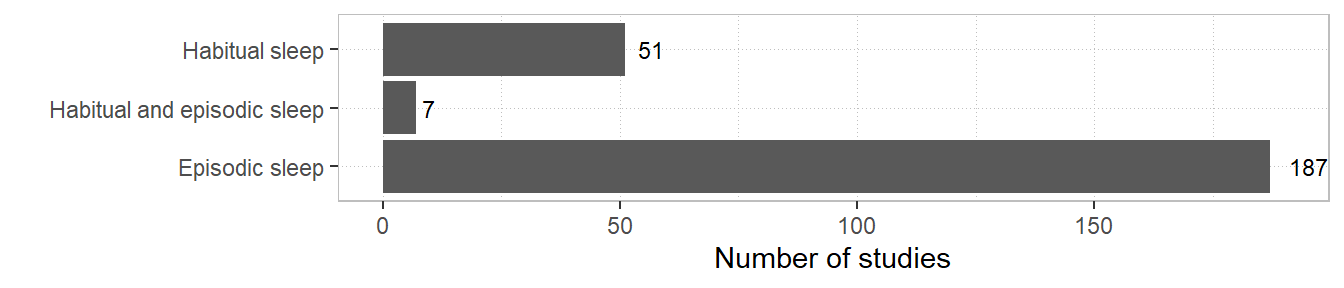


Figure 4.11: Habitual or episodic sleep

4.3 Sleep variables

A range of variables were used to operationalise sleep discrepancy. These are listed below in Table [4.1](http://127.0.0.1:10065/rmd_output/0/#tab:variables) with their usual definitions and equivalent terms.

| Table 4.1: Sleep variables used for operationalising sleep discrepancy | | | |
| --- | --- | --- | --- |
| **Variable** | **Abbreviation** | **Calculation** | **Equivalent terms** |
| Total sleep time | TST | Varied (Objective, Self-report) | Sleep duration |
| Sleep onset latency | SOL | Varied (Objective) | Sleep latency (SL) |
| Wake after sleep onset | WASO | Varied (Self-report) |  |
| Sleep efficiency | SE | Varied (Self-report, Objective) | Sleep efficiency index (SEI) |
| Time in bed | TIB | BT - RT |  |
| Number of awakenings | NWAK |  |  |
| Total wake time | TWT | SOL + WASO + terminal wakefulness (TWAK) |  |
| Sleep period time | SPT | BT - FWT |  |
| Sleep onset time | SOT | Time at sleep onset | Sleep onset (actigraphy) |
| Final wake time | FWT | Time at final awakening |  |
| Bed time | BT | Time where participant is in bed trying to sleep | Lights off (PSG) |
| Rise time | RT | Time getting out of bed | Sleep offset (actigraphy), lights on (PSG) |
| Sleep midpoint |  | (FWT - BT)/2 |  |
| Binary Sleep-Wake agreement |  |  |  |
| Confusion Matrix Sleep-Wake agreement |  |  |  |
| Latency to persistent sleep | LPS | Latency to 10 minutes of uninterrupted sleep |  |
| Sleep during subjective latency | SDSL | Minutes of objective sleep during period defined by self-report sleep latency |  |
| Latency-adjusted total sleep time | LA-TST | Objective total sleep time following the point of subjective sleep onset |  |
| Effective sleep time | EST | TST - WASO - SOL |  |
| Subjective wake time | SWT | WASO + SOL |  |
| Terminal wakefulness | TWAK\* | RT - FWT | Wake after sleep offset (WASF) |
| Intermittent wake time | IWT | No definition reported |  |
| *Note:*Binary sleep-wake involved measuring at one or multiple instances whether a participant’s reported sleep state matched the objective sleep state upon which the query was conditional (e.g., participants were only queried during objectively-confirmed sleep). On the other hand, confusion matrix sleep-wake involved measuring at one or multiple instances whether a participant’s reported sleep state matched an objective sleep state that was allowed to vary independent of the query (e.g., participants were queried at a certain time point irrespective of sleep state). The states were called so as the former approach produces a binary outcome whereas the latter produces a confusion matrix. | | | |
| \*TWAK was not used to define sleep discrepancy directly by any of the included studies but is included in the table for clarity | | | |

The number of studies that used each sleep variable are depicted below in Figure [4.12](http://127.0.0.1:10065/rmd_output/0/#fig:vargraph).

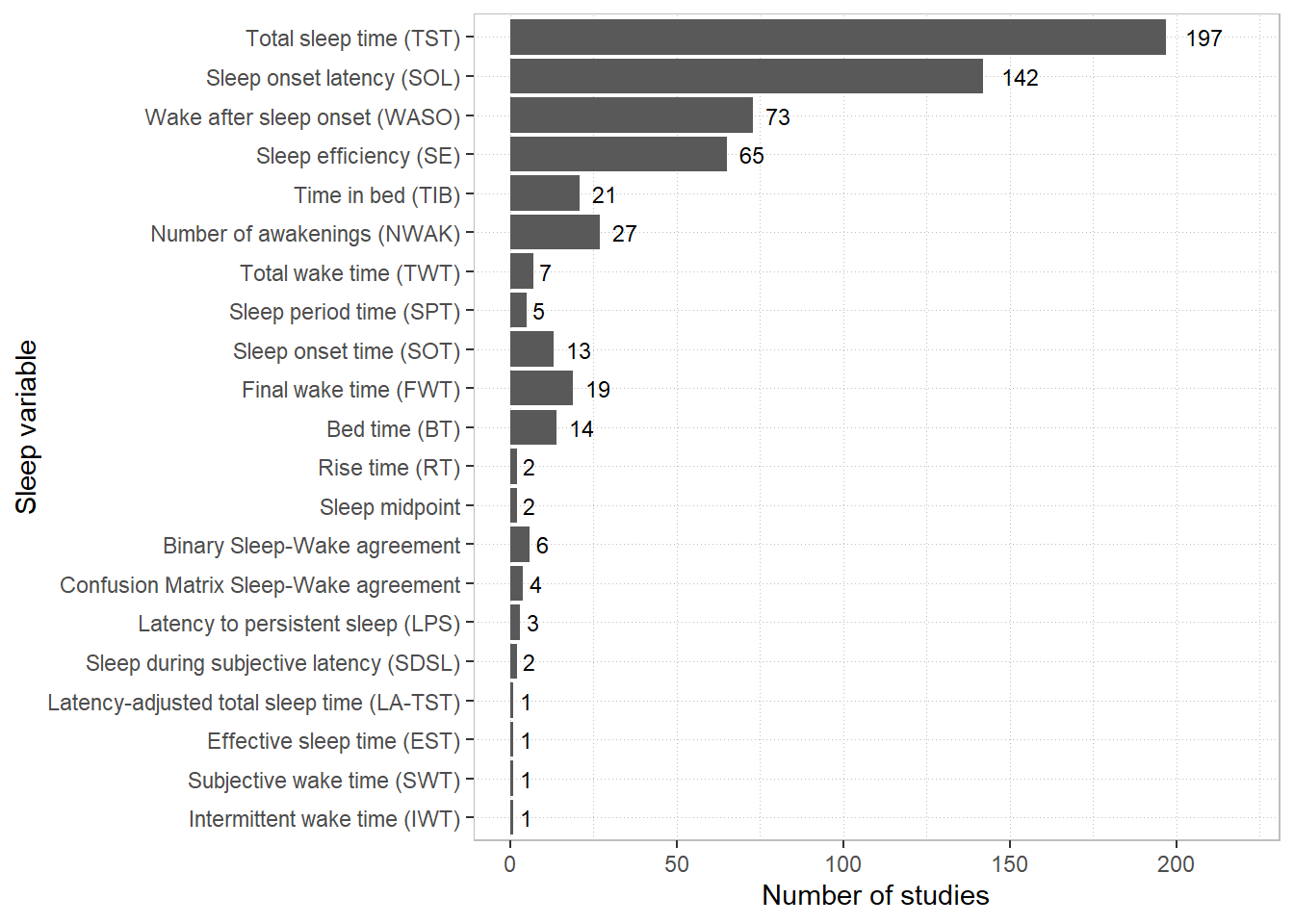


Figure 4.12: Sleep variables

The sleep variables TST, SOL, WASO, and SE were most common and formed the majority of identified parameters. Direct sleep-wake agreement was measured by a small subset of studies. Almost all identified sleep variables were measures related to sleep time or awakenings, although we did note some more unconventional parameters listed below separately from the figure above. Allawati et al6 compared self-report and actigraphic measures of sleep patterns including monophasic, biphasic dawn, biphasic siesta, and polyphasic. Lockley et el48, Dautovich et al49, Hanisch et al50, and Nguyen-Michel et al51 reported discrepancy for naps specifically, including variables such as number of naps, number of days napped, mean duration of naps, and total nap time. Baek et al52 and Chan et al53 compared self-report and actigraphic assessments of variability in TST and other sleep parameters. Thun et al54 compared self-report and actigraphic measures of morningness-eveningness. Finally, McIntyre et al55 investigated self-report-objective discrepancy across a range of sleep behaviours including position at sleep onset, position at wake, number of positional changes, and the presence of leg twitches or jerks.

4.3.1 Self-report sleep variable definitions

Calculation of self-report TST, WASO, SE, and TIB varied across studies. Variations across three major types of self-report TST were observed: TST queried directly (e.g., “how many minutes did you sleep last night”, TST calculated from other parameters such as TIB, SOL, and WASO, and TST calculated from graphical responses. The results for TST definitions are depicted in Figure [4.13](http://127.0.0.1:10065/rmd_output/0/#fig:tstdefinitions) below.

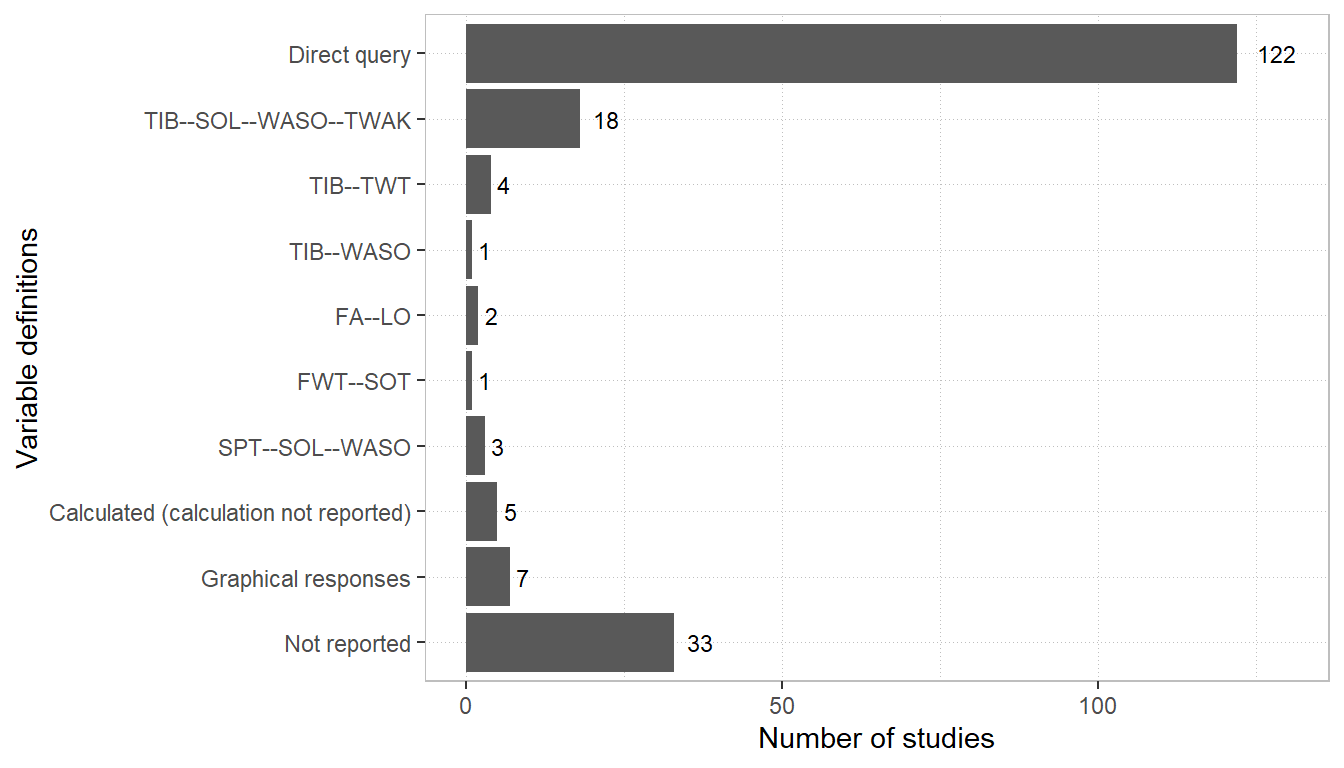


Figure 4.13: Self-report TST definitions

Note, FA–LO indicates lights off to final awakening. By conventional definitions of SPT, SPT–SOL–WASO is equal to TIB–SOL–WASO–TWAK, but is listed separately above to reflect differences in terminology. Definitions for WASO also varied and these are depicted in [4.14](http://127.0.0.1:10065/rmd_output/0/#fig:wasodef) below.

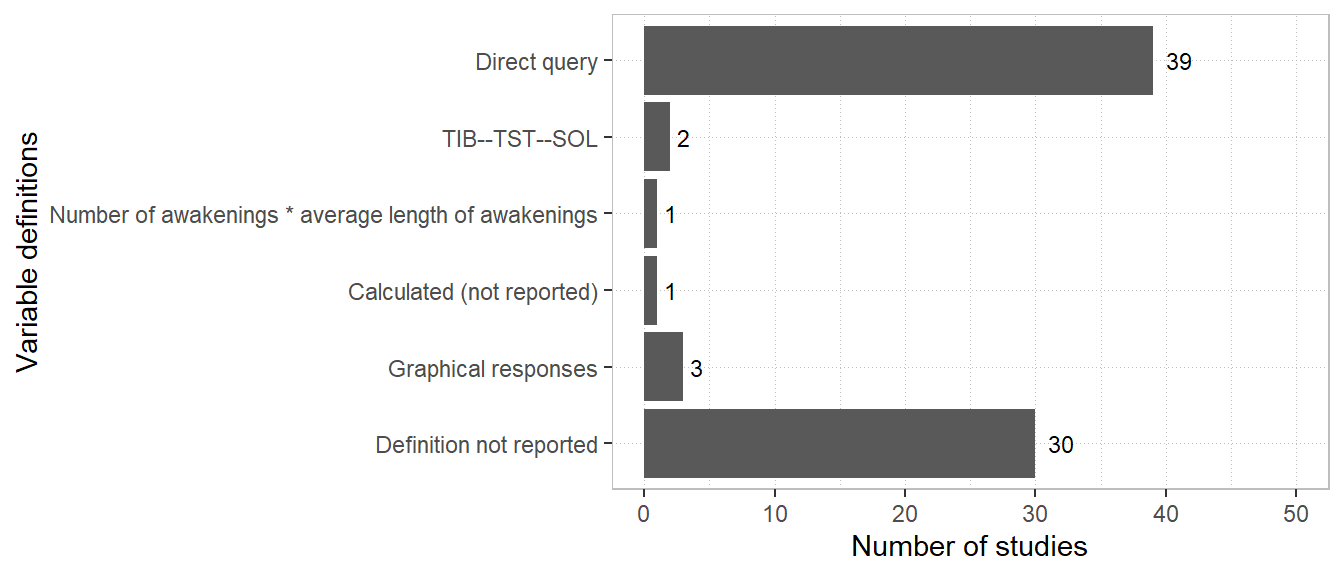


Figure 4.14: Self-report WASO definitions

Definitions for self-report TIB used in operationalising sleep discrepancy are depicted Figure [4.15](http://127.0.0.1:10065/rmd_output/0/#fig:tibdef).

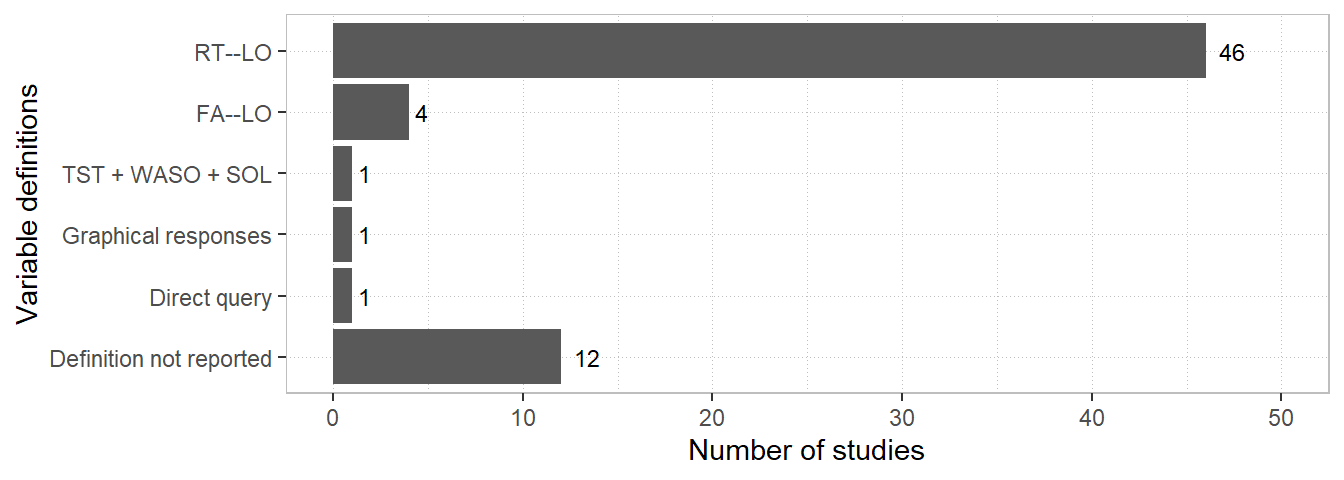


Figure 4.15: Self-report TIB definitions

Note, RT–LO refers to the time between lights off and rise time. SE was almost unanimously calculated as TST/TIB\*100 , although varying definitions for the TST and TIB components affect this outcome. One study56 used two definitions of SE, one comprising TST/TIB and the other TST/sleep period time (SPT).

4.3.2 Objective sleep variable definitions

Objective TST was defined very consistently with the exception of Sinclair et al57 who, in addition to providing a standard definition for TST, measured TST across a 24-hour period, such that time spent asleep outside the usual nocturnal period (i.e., naps) contributed to this measurement. Objective definitions for SOL varied considerably and these are depicted in Figure [4.16](http://127.0.0.1:10065/rmd_output/0/#fig:SOL) below.

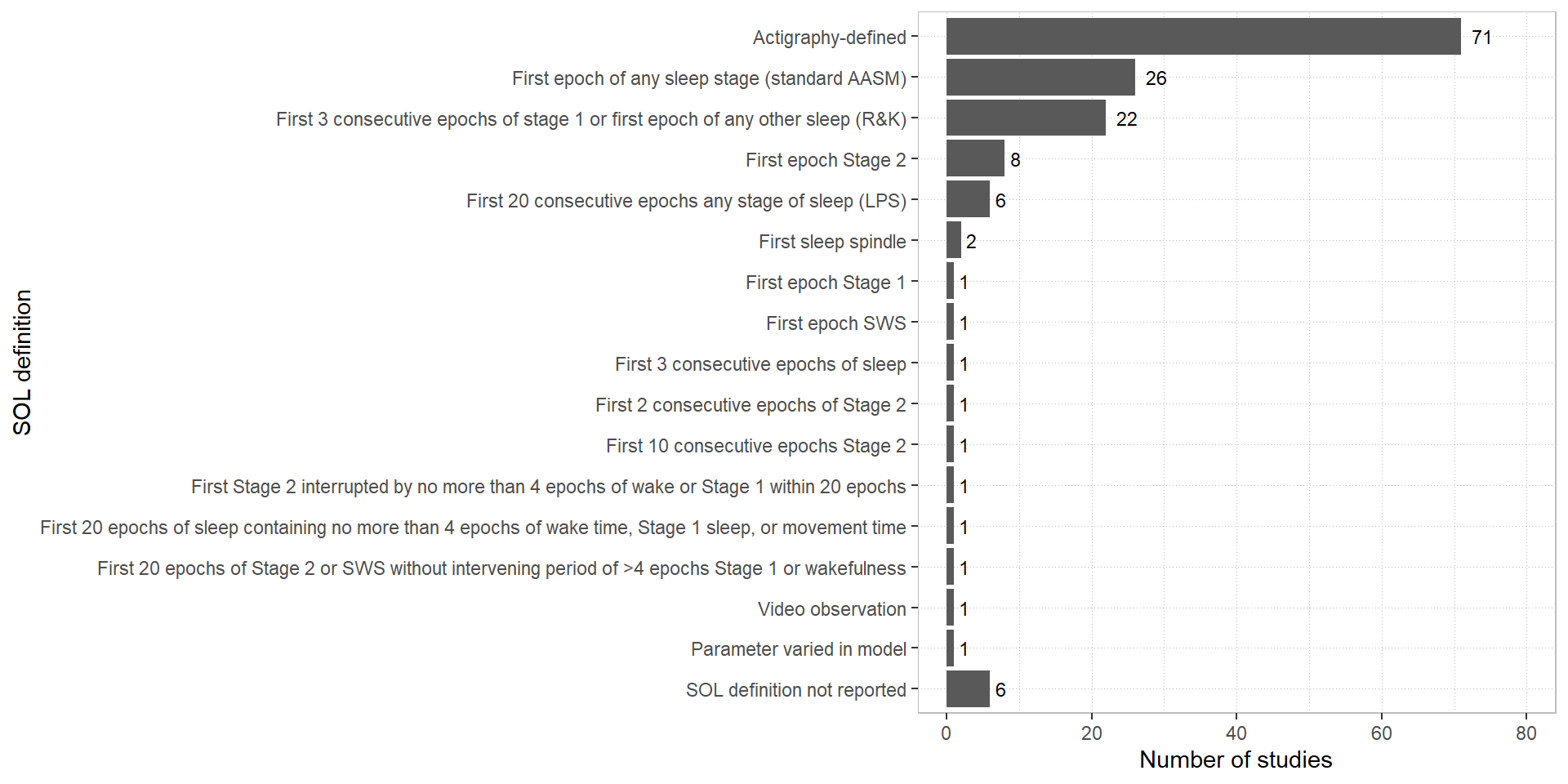


Figure 4.16: SOL definitions

Note that SWS = slow wave sleep, LPS = latency to persistent sleep, AASM = American Academy of Sleep Medicine guidelines, R&K = Rechstaffen & Kales guidelines. Parameter varied in model indicates that the definition of sleep onset was varied within the context of a predictive model. Among PSG studies, the two most common approaches were dependent on standard definitions provided by the R&K58 and AASM59 scoring guidelines.

Most studies used standard PSG or actigraphy criteria for defining objective number of awakenings (i.e., a single epoch of wakefulness). A single exception was Lewis et al60, who stipulated that a period last over a minute to count as an awakening. Neu et al56 used the same definitions for objective SE as they did for self-report SE.

4.3.3 Sleep quality

Sleep quality discrepancy was measured by 14 studies using (on the self-report side) sleep quality ratings (n = 8), PSQI total scores (n = 3), sleep quality factor scores (n = 1), sleep depth ratings (n = 1), or sleep quality composite scores (n = 1). On the objective side, sleep quality measures included SE (n = 7), factor scores from sleep variables (n = 2), sleep architectural variables (n = 7), N3 sleep quantity (n = 1), TWT (n = 1), and a composite variable formed from SOL, WASO, and SE (n = 1). Although approaches varied substantially, the most common combination of sleep quality measures was a sleep quality rating and SE.

4.4 Method of handling repeated measurements

Sleep data often involves repeated measurements of the same individual. Actigraphy and sleep diaries usually involve data collection across 7 to 14 days and multiple consecutive nights of PSG are sometimes recorded. Methods for handling repeated measurements are depicted below in Figure [4.17](http://127.0.0.1:10065/rmd_output/0/#fig:methodrm)

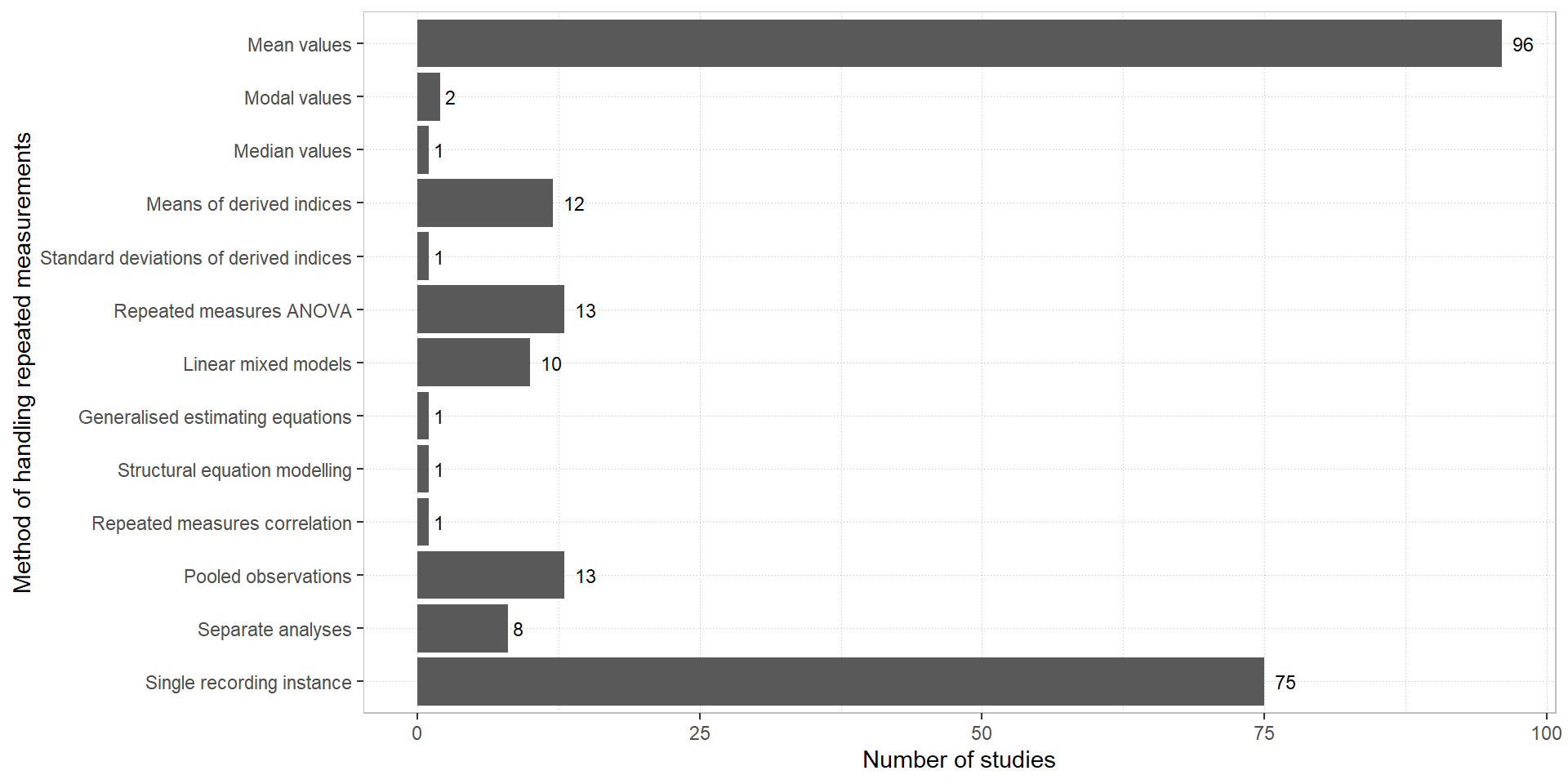


Figure 4.17: Methods for handling repeated measurements

Note that pooled observations involved collapsing data across multiple instances of recording. Separate analyses indicate that analyses were conducting separately for each instance of recording. In addition to the above, some studies measuring naturalistic sleep in the home environment took day of week into consideration for analyses. Three studies calculated a weighted average for sleep variables equal to 5/7\* (mean weekday sleep) + 2/7\* (mean weekend sleep), and 9 performed analyses for weeknights and weekends separately.

4.5 Direct comparisons of self-report and objective sleep

A total of 172 studies measured sleep discrepancy at the group level by directly comparing self-report and objective sleep. Methods for achieving this varied and are depicted below in Figure [4.18](http://127.0.0.1:10065/rmd_output/0/#fig:group)

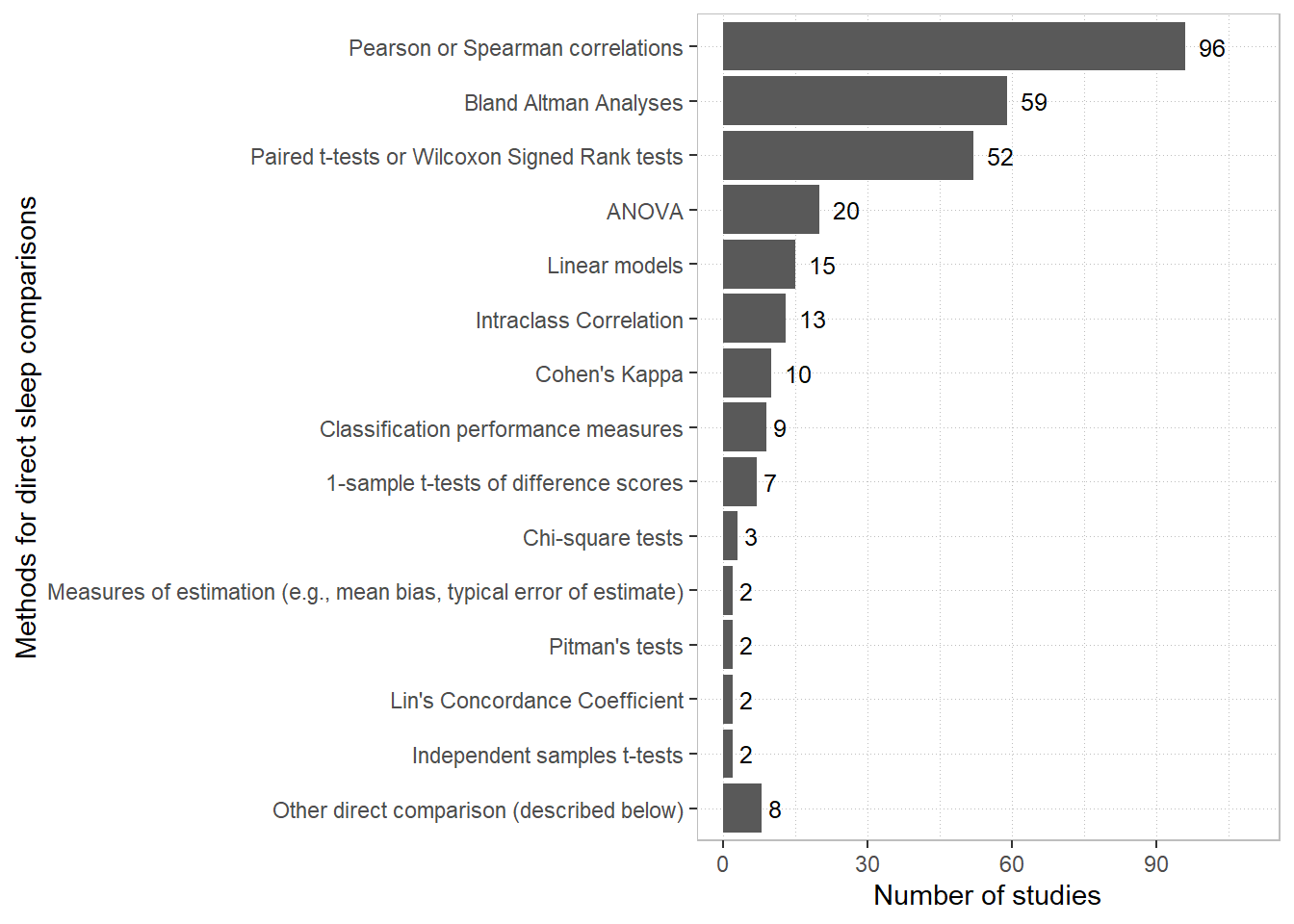


Figure 4.18: Statistical methods for comparing self-report and objective sleep

Note, Bland Altman analyses include Bland Altman plots and the reporting of 95% limits of agreement61. Pitman’s test (also known as the Pitman-Morgan test) is a test of differences of variances between dependent samples62,63 and was used to compare the variability of self-report and objective sleep. One-sample *t*-tests of difference scores are equivalent to paired *t*-tests but are included separately in the figure to reflect differences in reporting. Classification performance measures include percentage agreement, accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Formulae used for the intra-class correlation coefficient varied across studies. Spearman correlations and Wilcoxon Signed Rank Tests were often used to handle the skew of variables such as SOL and WASO. Other methods included the delta coefficient64, partial correlation and factor analysis65, errors-in-variables regression66, repeated measures correlation67, non-parametric limits of agreement68, survival agreement69, latent correlations for testing associations at within-subjects and between-subjects level70, and structural equation modelling71.

4.6 Methods for investigating the relationship of sleep discrepancy with other variables

A total of 133 studies aimed to investigate the relationship of sleep discrepancy with other variables of interest. Most studies achieved this by operationalising sleep discrepancy on the individual level through the calculation of a derived index.

4.6.1 Derived indices

Approximately half (n = 128) of included studies calculated a derived index (e.g., self-report TST–objective TST) to operationalise sleep discrepancy. Some studies used indices directly in statistical analyses (n = 107) whilst others used indices to divide samples into groups (n =18) either dichotomising (n = 12) or trichotomising (n = 6) derived score values. Methods for deriving indices varied across studies and can be broadly categorised into four groups: arithmetic difference scores, where one measure is simply subtracted from the other (e.g., sTST–oTST); absolute difference scores, composed of the absolute value of algebraic difference scores (e.g., |sTST–oTST|); ratio scores, when one measure is divided by the other (e.g., sTST/oTST); and combination scores that incorporate both subtraction and division of component measures (e.g., oTST–sTST/oTST). A list of indices including the number of studies that used them are provided in Figure [4.19](http://127.0.0.1:10065/rmd_output/0/#fig:derived) below.

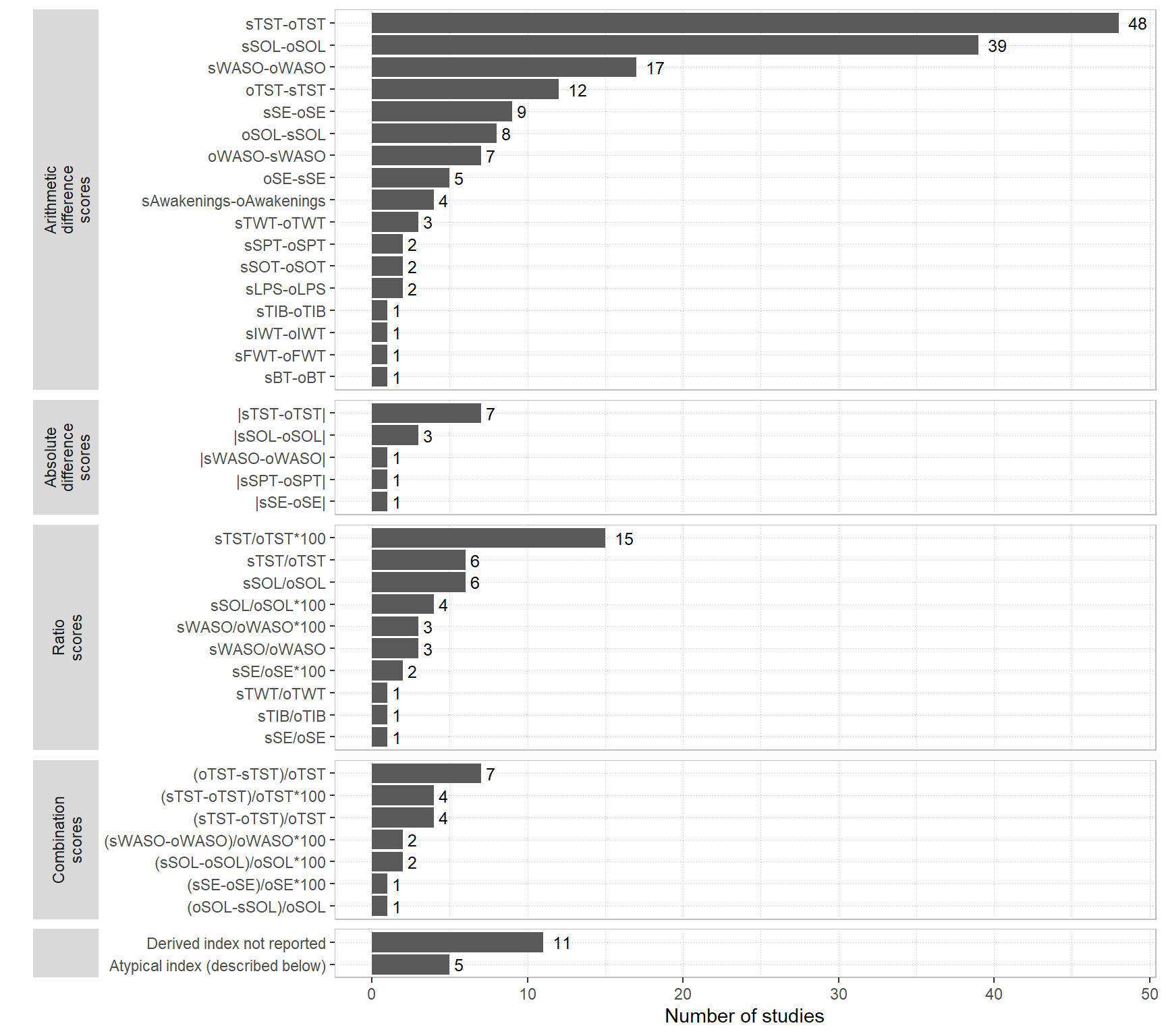


Figure 4.19: Derived indices used for operationalising sleep discrepancy

Overall, the sleep variables TST, SOL, and WASO represented the substantial majority of derived indices. Arithmetic difference scores were the most common derived index and with these objective sleep was subtracted from self-report sleep considerably more often than vice-versa. By contrast, ratio scores did not differ in directionality, and all that were recorded featured self-report sleep as the numerator and objective sleep as the denominator. Absolute differences are unique amongst derived indices for operationalising negative sleep discrepancy as equal to positive sleep discrepancy. With the relatively few absolute difference scores noted here it appears that the literature has mostly conceived of sleep discrepancy as a directional concept. All the combination scores identified followed the general format of an arithmetic difference score divided by a component of the difference.

A handful of more atypical derived scores were identified. Jackowska et al72 created a sleep quality discrepancy index by subtracting a z-transformed self-report sleep quality rating from z-transformed objective SE. Kay et al73 derived a nightly variability index for sSOL–oSOL and sWASO–oWASO by dividing intra-individual standard deviations by the sample-wise standard deviation for each variable. Mendelson et al74 divided self-report sleep following experimental awakenings by objective sleep following experimental awakenings. Winer et al75 derived a difference score from subtracting composite scores composed of the average of z scores of TST, SE, and sleep fragmentation (number of awakenings/SPT\*100) from z-transformed PSQI total scores.

4.6.2 Other methods for operationalising sleep discrepancy

A number of other ways to characterise the relationship of sleep discrepancy with other variables of interest were identified and are depicted in Figure [4.20](http://127.0.0.1:10065/rmd_output/0/#fig:otherm) below. Some studies operationalised sleep discrepancy using an interaction term within an ANOVA or other linear model such that the other variable(s) of interest was/were instantiated as the moderator of the relationship between self-report and objective sleep. Others used percentage agreement for sleep or other classification performance metrics in subsequent statistical analyses with other variables. Differences between correlations amongst self-report and objective sleep between groups were also tested with bootstrapped confidence intervals77, or the Fisher transformation78. studies operationalised sleep discrepancy with the Sleep Fragment Perception Index (SFPI), an index that exploits the fact that longer sleep fragments are more likely to be identified as sleep by individuals than shorter fragments79. The SPFI is a parameter modelled to assume the shortest length of objective sleep that is perceived as subjective sleep. For the SFPI, a higher value corresponds to a longer sleep fragment necessary for subjective awareness of sleep and hence greater sleep discrepancy.

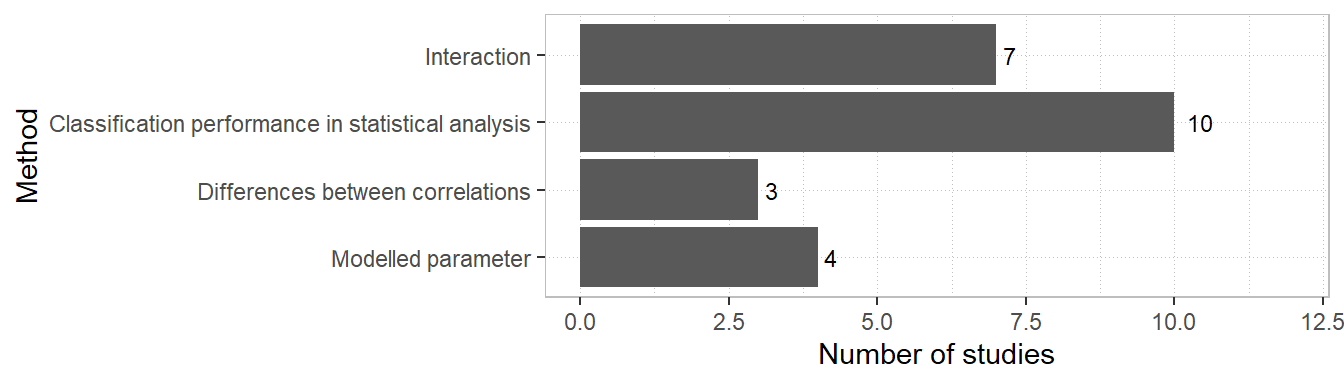


Figure 4.20: Other methods for operationalising sleep discrepancy

4.7 Miscellaneous methodological features

Lastly, we recorded some other methodological features of studies that appeared pertinent to the study of sleep discrepancy. Eleven studies investigated sleep discrepancy during, as a predictor of response to, or as an outcome of, cognitive behaviour therapy for insomnia (CBT-I). Fifteen studies used an experimental awakening paradigm where participants were monitored in-lab and woken by sound probes or technician interventions. A total of 15 studies were conducted with the aim of validating or assessing a particular sleep instrument.

5 Discussion

This study systematically reviewed ways of measuring, conceptualising, and analysing sleep discrepancy. Studies varied considerably across the broad range of recorded methodological characteristics and the number of studies identified indicated a vast literature. At the level of measurement, objective sleep mostly consisted of polysomnography and actigraphy, whilst self-report sleep spanned a range of questionnaires and diaries of varying response formats. Within objective sleep measures, approaches varied according to setting, equipment, and algorithms and procedures to process data. Sleep time-related metrics (e.g., TST, SOL, WASO) preponderated in the identified studies, with a small minority measuring direct sleep-wake agreement and a handful of studies measuring other sleep-related features or behaviours. Sleep quality was also investigated by a small number of studies. Definitions for sleep variables themselves did vary across studies although mainly on the self-report side and principally for the variables TST, WASO, and TIB, although objective SOL varied considerably. At the level of data processing and analysis, a range of strategies were employed to accommodate repeated measurements but for many studies, too, there was a single instance of recording. Direct comparisons were commonly made between self-report and objective sleep and these spanned a number of statistical approaches. Many studies went further than comparing self-report and objective sleep directly and attempted to investigate the relationship between sleep discrepancy and other variables. This was achieved most often with derived indices (e.g., self-report TST–objective TST), although other strategies were also employed. Our findings are discussed below with recommendations for further research where relevant.

5.1 Methodological diversity in sleep discrepancy research represents a conceptual problem

In attempting to measure the discrepancy between two concepts it is useful to know the discrepancy—or variability—within each concept itself. This is so that it can be certain that the discrepancy being measured cannot be accounted for by the amount of variation within each concept. Our results indicate that “self-report sleep” or “objective sleep” are not monolithic entities but variegated in ways that may be important. Take, for example, the simplest methodological distinction in objective sleep measurement: polysomnography versus actigraphy. In comparison with PSG, actigraphy generally overestimates sleep and underestimates wake time, and can have trouble distinguishing sleep from quiescent periods of wakefulness80. These trends have been observed to be greater for samples experiencing chronic medical or psychiatric conditions81. Tryon82 has emphasised that these differences between polysomnography and actigraphy are systematic, rather than random, and it follows from this that the two forms of objective sleep measurement will form distinct kinds of sleep discrepancy.

This issue continues through finer methodological distinctions. For example, within actigraphy, estimation of sleep can vary substantially across the various scoring algorithms identified in this review. There is ample evidence indicating that the concordance of actigraphy to PSG by algorithm can vary according to the sample in question83–86 and algorithm performance can even vary based on the actigraph device used87. A further example can be represented by the sheer range of sleep variables available to operationalise sleep discrepancy. Discrepancy within each variable is likely to have a distinct theoretical meaning. For example, Castelnovo et al7 noted that little overlap was found between individuals that misperceive TST and misperceive SOL. Important distinctions continue even within sleep variables themselves. We identified a range of self-report TST definitions, with the most common being direct queries (e.g., “how many hours did you sleep last night?”) and calculated parameters (e.g., TST = TIB–SOL–WASO–TWAK). Alameddine et al88 compared these two definitions and found that calculated estimates tended to exceed those from direct queries. TST discrepancy was overall negative across their sample for those with and without insomnia and so it is possible that indirect queries produce self-report TST that is closer to objective estimates.

For each of these examples, there are differences in sleep discrepancy across methodological approaches that evidence indicates is likely to be systematic. This is a significant issue for studies investigating the relationship between sleep discrepancy and another construct as the variance accounted for by the span of possible approaches may well exceed that of the effect the researchers are looking for. Addressing this issue may take a number of approaches. A stronger research focus on methods, investigating the impact of changes in methodology would be helpful overall. Specific tools such as structural equation modelling could be used to account for the variance represented by various methodological choices alone or in relation to other constructs. Theoretical justification or some rational account should also be provided for selection of sleep variables where possible, as many are likely to be conceptually distinct. A standardised approach to conducting and scoring actigraphy would reduce methodological variance in this particular area.

5.2 Methodological diversity may influence the rate of false-positive findings

Methodological diversity may also have consequences on the rate of false-positives in the sleep discrepancy literature. The term *researcher degrees of freedom* has been used to refer to the range of possible decisions throughout the data collection and analysis process that can be exploited to yield tests that reach statistical significance89. As evidenced by this review, the amount of researcher degrees of freedom in sleep discrepancy research is considerable, particularly at the data analysis stage, and especially for sleep variable definition and selection. Any combination of the large number of sleep variables identified in this review may be chosen as an alternative analytic decisions during analysis. When the different possible definitions of each of these variables are also enumerated, the number of possible decisions seems endless. Note, this issue is not confined to the case of a researcher deliberately exploring analytical alternatives following a null result. In a problem referred to as the garden of forking paths90, any methodological decision made in response to an observed feature of the data increases the likelihood that findings will be misleading. An example of this would be selecting SE over TST for a subsequent analysis after observing that SE discrepancy best discriminated individuals with and without insomnia. Even though the eventual result is at this point unknown, the decision of sleep variable is contingent on the data, and ultimately, *p*-values will not reflect what would have happened had TST been chosen instead. For any study investigating the relationship of sleep discrepancy with other constructs, pre-registration of hypotheses and plans for data collection and analysis91 is likely to be helpful in minimising inflated Type I error through post-hoc methodological decisions.

5.3 Definitions of objective sleep onset latency are multifarious and mostly arbitrary

Definitions of objective SOL vary considerably in the sleep discrepancy literature. Self-report sleep onset is more likely to coincide with the occurrence of the first sleep spindle, an EEG waveform associated with stage 2 sleep, than with the first incidence of stage 1 sleep92. As such, R&K SOL is likely to have greater correspondence to self-report SOL than AASM SOL. This disparity would be expected to increase with greater sleep fragmentation in the early sleep period and substantial differences in AASM and R&K sleep discrepancy should be expected in samples with disrupted initial sleep. Stricter/longer SOL definitions including the Latency to Persistent Sleep (LPS)93 and complex definitions from Means et al3 and Lehrer et al94 are expected to have the closest correspondence to self-report SOL, as research indicates 22-minutes of uninterrupted sleep is needed for healthy adults to perceive a bout of sleep during the beginning of the night95.

Sleep onset is a continuous process for which it is difficult to identify a clear start-point82. For example, with PSG scored by AASM criteria, 50% of a 30-second epoch is needed to exhibit sleep for the scoring of a first sleep stage. This means sleep latency is defined as the number of epochs preceding the first uninterrupted ~16 seconds of an EEG depicting activity consistent with sleep. An individual could conceivably achieve this 16-second threshold within two minutes, wake up, and not return for another two hours (SOL = 2 minutes). Equally, an individual could spend a two hour period getting 14-second blocks of sleep before achieving a consolidated bout of sleep (SOL = 120 minutes). These are extreme examples, but they highlight the difficulty with defining a single point of sleep onset. Of course, a line needs to be drawn somewhere, but the position of this line appears to be an arbitrary decision.

Saline et al96 noted another problem although only for studies that investigate both TST and SOL concurrently. In the estimation of TST, individuals may attempt to judge the length of time between their subjective sleep onset and final wake time—anchoring their TST estimate to their SOL estimate. In measuring TST and SOL discrepancy, SOL discrepancy is thus being tested for twice: once in SOL and again implicitly in TST. Their solution to this problem was to obtain independent measurements by estimating the amount of objective sleep measured during the subjective sleep latency period (sleep during subjective latency; SDSL) and the amount of objective sleep measured following the subjective sleep latency period (latency adjusted total sleep time; LA-TST).

In view of these issues, three options are recommended in the context of sleep discrepancy research. The first is to proceed with defining objective SOL using latency to persistent sleep (LPS)—the first 20 consecutive epochs of sleep. Due to the considerable time it takes to perceive a bout of sleep and the rarity and limited magnitude of SOL underestimation95,96 it makes sense to use a longer criterion than a shorter one. LPS also has the advantage of being simpler than many of the alternatives we identified. The second option is to use SDSL for the reasons described in the previous paragraph. It should be noted, however, positive discrepancy (i.e., SOL underestimation) is not measurable with this method. The third option is to avoid SOL as a sleep variable and to model sleep perception parameters during the sleep onset period according to Hermans et al95. The latter two options have the added advantage of operationalising sleep discrepancy without the use of derived scores—the problems with which are discussed briefly in a following paragraph.

5.4 Sleep discrepancy is mostly restricted to sleep states or sleep time and varies in its conceptual distance to sleep misperception

To map the boundaries of the concept of sleep discrepancy, we included any studies comparing objective sleep with an equivalent measure of self-report sleep. From the very few studies identified investigating sleep patterns or other sleep-related behaviours it appears that sleep discrepancy is mostly restricted to discordance in sleep states (e.g., wakefulness versus sleep) or discordance in sleep time parameters (e.g., total sleep time). It may be helpful to consider sleep discrepancy, as so defined, in relationship to sleep misperception. These two terms have been used interchangeable in the past and the problems with doing this have been noted by a number of authors82,97. Stated simply, sleep is a complex process for which there no one perfectly valid measure, and using the term *sleep misperception* brings a status to objective measures of sleep that may not be warranted. For example, sleep-like EEG activity can occur during waking consciousness in a phenomenon known as local sleep98, and other dissociations between the EEG and sleep-related physiological processes, have been observed under some conditions99. Moreover, conventional sleep scoring is but one way of classifying EEG data and subtler systems exist, including the cyclic alternative pattern100.

Whilst it may not be possible to directly measure sleep misperception for these reasons, sleep discrepancy can be closer or further to sleep misperception conceptually depending on its operational definition. Closest are studies measuring sleep-wake agreement or classification using EEG under laboratory conditions. In a case where a participant who, being asleep for five minutes, is woken by a technician and reports complete wakefulness for the preceding period, only the fallibility of objective recording can account for a conceptual distinction between sleep discrepancy and true sleep-state misperception. This fundamental sleep discrepancy represented by direct sleep-wake agreement can be contrasted with sleep discrepancy represented by sleep time variables (e.g., TST, SOL). Moving from sleep-wake agreement to sleep time variables introduces additional factors that may account for the incongruence between self-report and objective sleep and hence provides a broader definition of sleep discrepancy. On the objective side, PSG potentially introduces artefact from transient (e.g., <15 second) awakenings101 and the arbitrary nature of SOL definitions (see section [5.3](http://127.0.0.1:10065/rmd_output/0/#sol)). Actigraphy introduces the potential for immobile wake to be scored as sleep84,102 and variance contributed by methodological factors such as choices in scoring algorithms. On the self-report side, sleep diaries and questionnaires introduce memory or reporting biases103 as potential factors contributing to sleep discrepancy. See Harvey et al104 for a discussion of these factors in the context of insomnia. In the present review, we reported a key distinction between *habitual* and *episodic* measures of self-report sleep.

Moving from episodic to habitual measures broadens the concept of yet sleep discrepancy further. A more global sleep discrepancy may be represented by comparisons of habitual self-report sleep with aggregated objective sleep (e.g., mean sleep variables values across 14 nights of actigraphy), the underlying processes for which are likely different to those of individual nights. Where habitual self-report sleep is compared to objective estimates spanning one to a few nights, intra-individual variation in sleep patterns is introduced to sleep discrepancy. In other words, some component of the difference between objective and self-report sleep can be accounted for by the difference between habitual sleep and the circumstances of testing—which may be substantial. If the objective measure is PSG, effects of the laboratory/testing environment (i.e., the first night effect105,106) are additionally introduced.

5.5 Derived indices are common and the use of these as an operational measure of sleep discrepancy is problematic

Derived variables, including difference scores and ratio scores, are overwhelmingly the most common way of operationalising sleep discrepancy to investigate its relationship with other variables. The use of derived variables for such a purpose is associated with a range of conceptual and methodological problems107–109 that are severe enough to warrant discontinuing their use in sleep discrepancy research. Stated briefly, in a relationship with another variable, the effect of each component of a derived index (e.g., a difference score representing the subtraction of self-report from objective TST) is confounded such that it is not possible to determine whether self-report sleep, objective sleep, or some combination of the two are driving the relationship108. Moreover, derived scores impose inappropriate constraints on relationships between other variables that are often not entailed by, or else completely contradictory to, stated hypotheses108. A large range of derived variables were identified by this review, none of which escape the problems described by the aforementioned authors. Fortunately, a number of alternative strategies for characterising relationships between sleep discrepancy and other constructs are available. Such methods identified in this review included using classification performance metrics within conventional statistical analyses, representing sleep discrepancy with moderation/interaction effects, and modelling sleep discrepancy parameters mathematically.

5.6 Averaging sleep variables across multiple nights is a common practice and can cause problems

In the studies identified in this review, the most common way of handling repeated measurements of sleep variables was by averaging across multiple instances of recording. This technique is problematic when applied to concurrent nightly/episodic measurements of self-report and objective sleep as it relies on the assumption that patterns of sleep over/underestimation are consistent across nights. Extreme positive and negative sleep discrepancy occurring alternately on successive nights could result in averages denoting negligible discrepancy. This may be a realistic concern for research in sleep discrepancy and insomnia, for example. Although most individuals with insomnia tend to underestimate sleep, high inter-night variability is observed and some individuals will overestimate sleep110. An exception to this problem exists in the case of comparing aggregated objective sleep against a habitual measure of self-report sleep, such as the PSQI. Here, using means or medians to determine habitual measures of objective sleep is necessary to define sleep discrepancy at the habitual, rather than the nightly level. In other cases, linear mixed models, generalised estimating equations, and structural equation models were methods identified in this review that do not inherit the same problems with averaging across repeated measures.

5.7 Correlations have sometimes been used inappropriately as a measure of concordance

Despite being the most common approach to comparing self-report and objective sleep measures, Pearson or Spearman correlations are broadly inappropriate for the characterisation of agreement or discrepancy. Correlation is strictly a measure of association between two variables and is insensitive to systematic error between measures111. For example, the same correlation coefficient may equally describe a sample where self-report and objective estimates of sleep tend to be equal as one where (i), objective estimates tend to exceed self-report estimates by a given constant (e.g., two hours) or (ii), the value of objective sleep varies proportional to the level of self-report sleep. Measures of agreement including Bland-Altman analyses, intra-class correlation, and Lin’s concordance coefficient were also used by a large number of studies and are preferable for the measurement of discrepancy in equivalent parameters.

5.8 Sleep quality discrepancy is conceptually unclear

Sleep quality discrepancy was measured by a small number of studies in this review, according to varying strategies. Sleep quality discrepancy is a difficult topic for two reasons. First, there is no consensus approach to operationalising sleep quality. A recent review of methods for measuring sleep quality identified an immense range in strategies, especially for objective measures112. Second, there are no clear self-report analogues for objective measures of sleep quality, or vice-versa. An individual is unable to directly estimate their number of EEG arousals, quantity or proportion of N3 sleep, or other features of sleep macro or microstructure unavailable to consciousness. Equally, it is not clear how to compare a sleep quality rating judgement (e.g., on a Likert scale) with objective measures (see Krystal & Edinger113). Overall, investigating the relationships of sleep quality discrepancy to other variables is unlikely to be profitable until the conceptual status of self-report and objective sleep quality is clearer.

5.9 Sleep diaries should not be used to define rest intervals in sleep discrepancy research

Sleep diaries were the most commonly identified method of rest interval definition in this review. Sleep diaries were classified by this review as a self-report measure of sleep. By using sleep diaries to define actigraphic rest intervals, self-report sleep is being used to partially define an objective sleep measure. In this case, the measured discrepancy between the two forms of sleep measurement will not be an accurate representation of their actual incongruence. The high frequency at which sleep diaries are back-filled or misreported103 highlights the significance of this issue. We noted that a single study in the present review addressed this problem directly. Krahn et al114 ensured that manual scorers of the rest intervals for their actigraphy data were blinded to the sleep diary. It may be helpful for further research that alternatives such as these are sought for defining rest interval periods.

5.10 The scope of sleep discrepancy research is likely to have been underestimated

The scope of the literature on sleep discrepancy has been considerably underestimated to date. We intended to identify a broad range of studies in this review that may have captured the concept of sleep discrepancy without necessarily referring to this or related terms. A search across full texts of all studies included in this review returned 63 records making explicit mention of “sleep” and “discrepancy”, leaving 185 that would have otherwise been unidentifiable through simple keyword searching of this concept. A prior review of paradoxical insomnia and subjective-objective sleep discrepancy8 identified a total of 40 records. Although conducted four years prior, this review used broader inclusion criteria extending to paradoxical insomnia, the parameters for which do not typically involve direct comparisons of self-report and objective sleep. A corollary to this underestimation of breadth is that existing sleep discrepancy research across domains may be excessively siloed into respective research areas. Looking at the clinical populations encompassed in this review, there appear to be small but distinguishable sleep discrepancy research programmes in post-traumatic stress disorder, bipolar disorder, pregnancy, traumatic brain injury, and fibromyalgia, to name just a few. Whilst sleep discrepancy is best understood in the context of insomnia, it is possible similar processes underlie the presence of sleep discrepancy in these groups. For example, the role of sleep disturbance as a transdiagnostic factor across psychiatric disorders has been emphasised115 and a mechanistic role for sleep misperception has been suggested for disorders outside of insomnia116.

5.11 Strengths and limitations

This study represents the largest systematic approach to investigating methodology in the area of sleep discrepancy research. We reported a broad range of methodological features across a large number of studies and provided meaningful syntheses of research methods in a diverse field. Two major changes were made to our own methods during the screening process and following registration of the scoping review protocol that may be viewed as limitations. These changes were both made in response to the unanticipated number of records returned following title and abstract screening and in view of limited resources available for charting and synthesis. First, grey literature was removed from inclusion criteria. Although the issues and recommendations discussed in this paper were limited to published research, our findings remain broadly applicable and no syntheses of empirical findings have been made that could be influenced by publication bias. Second, reference lists were not screened for additional studies and the extent to which this review may be considered an exhaustive representation of the literature may be reduced as a result.

5.12 Summary

Methods for investigating sleep discrepancy have varied considerably in the literature across the areas of study design, measurement, data processing, and data analysis. Many of these varied approaches have substantial effects on what sleep discrepancy means as a concept and sometimes are associated with methodological problems that may not be immediately clear. Sleep discrepancy research holds promise for advancing understanding of sleep, its disorders such as insomnia, and mechanisms at play in psychiatric and other disorders. Clear concepts and appropriate methodology is essential to ensure that work in this area remains a progressive science. Measuring discrepancy or congruence is often a deceptively complex undertaking and we hope that this scoping review will prove helpful and informative to those interested in designing or interpreting sleep discrepancy studies.

6 Data availability statement

All code and data underlying this article are available from github: <https://github.com/tfwalton/sleep-discrepancy-review>.

7 Acknowledgements

We would like to thank the librarians at the University of Western Australia library for their assistance with the development of the search strategy.

8 Financial disclosure statement

None.

9 Funding

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10 Declaration of competing interest

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

11 Appendices

11.1 Search strategies

Search strategies for databases searched using the Ovid system are available in Table [11.1](http://127.0.0.1:10065/rmd_output/0/#tab:ovid). Search strategies for other databases are listed in Table [11.2](http://127.0.0.1:10065/rmd_output/0/#tab:databases).

| Table 11.1: Search strategy for Ovid databases | | |
| --- | --- | --- |
| **Step** | **Terms and operators** | **Records** |
| **Embase** | | |
| 1 | sleep discrepancy or paradoxical insomnia or subjective insomnia or (sleep adj2 misperception).mp | 488 |
| 2 | ((self report\* or diary or subjective*) and (objective* or actigraph\* or polysomnograph\* or polygraph\*)).mp. | 193243 |
| 3 | (exp polysomnography/ or exp actimetry/) and exp self report/ | 1676 |
| 4 | (sleep\* and (“over estimat*” or ”over report*” or “under estimat*” or ”under report*” or overestimat\* or overreport\* or underestimat\* or underreport\* or discrepan\* or concordan\* or agreement or disagreement or discordan\* or congruen\* or incongruen\*)).mp. | 9362 |
| 5 | 2 or 3 | 193302 |
| 6 | 4 and 5 | 1234 |
| 7 | 1 or 6 | 1569 |
| **PsycINFO** | | |
| 1 | sleep discrepancy or paradoxical insomnia or subjective insomnia or (sleep adj2 misperception).mp | 175 |
| 2 | ((self report\* or diary or subjective*) and (objective* or actigraph\* or polysomnograph\* or polygraph\*)).mp. | 57592 |
| 3 | (exp polysomnography/ or exp actigraphy/) and exp self report/ | 59 |
| 4 | (sleep\* and (“over estimat*” or ”over report*” or “under estimat*” or ”under report*” or overestimat\* or overreport\* or underestimat\* or underreport\* or discrepan\* or concordan\* or agreement or disagreement or discordan\* or congruen\* or incongruen\*)).mp. | 2112 |
| 5 | 2 or 3 | 57592 |
| 6 | 4 and 5 | 346 |
| 7 | 1 or 6 | 471 |
| **Medline** | | |
| 1 | sleep discrepancy or paradoxical insomnia or subjective insomnia or (sleep adj2 misperception).mp | 260 |
| 2 | ((self report\* or diary or subjective*) and (objective* or actigraph\* or polysomnograph\* or polygraph\*)).mp. | 139088 |
| 3 | (exp polysomnography/ or exp actigraphy/) and exp self report/ | 561 |
| 4 | (sleep\* and (“over estimat*” or ”over report*” or “under estimat*” or ”under report*” or overestimat\* or overreport\* or underestimat\* or underreport\* or discrepan\* or concordan\* or agreement or disagreement or discordan\* or congruen\* or incongruen\*)).mp. | 5280 |
| 5 | 2 or 3 | 139088 |
| 6 | 4 and 5 | 692 |
| 7 | 1 or 6 | 875 |

| Table 11.2: Search strategy for other databases | |
| --- | --- |
| **Terms and operators** | **Records** |
| **Pubmed** | |
| (“sleep discrepancy” OR “paradoxical insomnia” OR “subjective insomnia”) OR (sleep AND misperception) OR ((“self report*” or diary or subjective*) AND (objective\* or actigraph\* or polysomnograph\* or polygraph*)) OR ((”Polysomnography/methods”[MAJR] OR ”Actigraphy/methods”[MAJR]) AND ”Self Report”[MeSH]) AND (sleep* AND (”over estimat*” OR “over report” OR ”under estimat” OR “under report*” OR overestimat\* OR overreport\* OR underestimat\* OR underreport\* OR discrepan\* OR concordan\* OR agreement OR disagreement OR discordan\* OR congruen\* OR incongruen\*)) | 761 |
| **CINAHL Plus** | |
| (“sleep discrepancy” OR “paradoxical insomnia” OR “subjective insomnia”) OR (sleep AND misperception) OR ((“self report*” or diary or subjective*) AND (objective\* or actigraph\* or polysomnograph\* or polygraph*)) AND (sleep* AND (”over estimat*” OR “over report” OR ”under estimat” OR “under report*” OR overestimat\* OR overreport\* OR underestimat\* OR underreport\* OR discrepan\* OR concordan\* OR agreement OR disagreement OR discordan\* OR congruen\* OR incongruen\*)) | 310 |
| **Scopus** | |
| TITLE-ABS-KEY ( ( “sleep discrepancy” OR “paradoxical insomnia” OR “subjective insomnia” ) OR ( sleep AND misperception ) OR ( ( “self report*” OR diary OR subjective* ) AND ( objective\* OR actigraph\* OR polysomnograph\* OR polygraph\* ) ) AND ( sleep\* AND (”over estimat*” OR “over report” OR ”under estimat” OR “under report*” OR overestimat\* OR overreport\* OR underestimat\* OR underreport\* OR discrepan\* OR concordan\* OR agreement OR disagreement OR discordan\* OR congruen\* OR incongruen\* ) ) ) | 826 |
| **Web of Science** | |
| (“sleep discrepancy” OR “paradoxical insomnia” OR “subjective insomnia”) OR (sleep AND misperception) OR ((“self report*” or diary or subjective*) AND (objective\* or actigraph\* or polysomnograph\* or polygraph*)) AND (sleep* AND (”over estimat*” OR “over report” OR ”under estimat” OR “under report*” OR overestimat\* OR overreport\* OR underestimat\* OR underreport\* OR discrepan\* OR concordan\* OR agreement OR disagreement OR discordan\* OR congruen\* OR incongruen\*)) | 1288 |
| **Proquest Theses and Dissertations Global** | |
| noft((“sleep discrepancy” OR “paradoxical insomnia” OR “subjective insomnia”) OR (sleep AND misperception) OR (((“self report*” or diary or subjective*) AND (objective\* or actigraph\* or polysomnograph\* or polygraph*)) AND (sleep* AND (”over estimat*” OR “over report” OR ”under estimat” OR “under report*” OR overestimat\* OR overreport\* OR underestimat\* OR underreport\* OR discrepan\* OR concordan\* OR agreement OR disagreement OR discordan\* OR congruen\* OR incongruen\*)))) | 90 |

11.2 List of deviations from protocol

The following are a list of deviations from the scoping review protocol registered on the Open Science Framework (doi: 10.17605/OSF.IO/BCJNQ).

1. The term actimetry in Medline and PSYCinfo searches was changed to actigraphy
2. The scoping review protocol listed an incorrect number of duplicates records following searches
3. All records that were not peer reviewed journal articles were excluded at the full-text screening stage in the final review
4. Other items were added to the exclusion criteria at the full-text screening stage including:

* study measured informant-report rather than strictly self-report sleep
* study did not include statistical comparison of self-report and objective sleep (e.g., numerical comparisons only, single-case design)

1. Reference lists were not searched for additional citations as planned in the protocol

11.3 PRISMA-ScR checklist

| Table 11.3: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist. | | | |
| --- | --- | --- | --- |
| **Section** | **Item** | **PRISMA-ScR Checklist Item** | **Location reported** |
| **Title** | | | |
| Title | 1 | Identify the report as a scoping review. | [1](http://127.0.0.1:10065/rmd_output/0/#abstract) |
| **Abstract** | | | |
| Structured summary | 2 | Provide a structure summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives. | [1](http://127.0.0.1:10065/rmd_output/0/#abstract) |
| **Introduction** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. Explain why the review questions/ objectives lend themselves to a scoping review approach | [2](http://127.0.0.1:10065/rmd_output/0/#introduction) |
| Objectives | 4 | Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualise the review questions and/or objectives. | [2](http://127.0.0.1:10065/rmd_output/0/#introduction) |
| **Methods** | | | |
| Protocol and registrations | 5 | Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number. | [3.1](http://127.0.0.1:10065/rmd_output/0/#protocol) |
| Eligibility criteria | 6 | Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale. | [3.2](http://127.0.0.1:10065/rmd_output/0/#item6) |
| Information sources | 7 | Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed. | [3.4](http://127.0.0.1:10065/rmd_output/0/#item7) |
| Search | 8 | Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated. | [3.1](http://127.0.0.1:10065/rmd_output/0/#tab:egsearch) |
| Selection of sources of evidence | 9 | State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review. | [3.5](http://127.0.0.1:10065/rmd_output/0/#item9) |
| Data charting process | 10 | Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators. | [3.6](http://127.0.0.1:10065/rmd_output/0/#item10) |
| Data items | 11 | List and define all variables for which data were sought and any assumptions and simplifications made | [3.7](http://127.0.0.1:10065/rmd_output/0/#item11) |
| Critical appraisal of individual sources of evidence | 12 | If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate). | Formal quality assessment was not conducted |
| Synthesis of results | 13 | Describe the methods of handling and summarizing the data that were charted | [3.8](http://127.0.0.1:10065/rmd_output/0/#item13) |
| **Results** | | | |
| Selection of sources of evidence | 14 | Give numbers of sources of evidence screen, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram. | [4](http://127.0.0.1:10065/rmd_output/0/#item14) |
| Characteristics of sources of evidence | 15 | For each source of evidence, present characteristics for which data were charted and provide the citations. | [11.4](http://127.0.0.1:10065/rmd_output/0/#tab:studychar) |
| Critical appraisal within sources of evidence | 16 | If done, present data on critical appraisal of included sources of evidence (see item 12). | Formal quality assessment was not conducted |
| Results of individual sources of evidence | 17 | For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives. | [4.2](http://127.0.0.1:10065/rmd_output/0/#resultsandsynthesis) |
| Synthesis of results | 18 | Summarize and/or present the charting results as they relate to the review questions and objectives. | [4.2](http://127.0.0.1:10065/rmd_output/0/#resultsandsynthesis) |
| **Discussion** | | | |
| Summary of evidence | 19 | Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups | [5](http://127.0.0.1:10065/rmd_output/0/#item19) |
| Limitations | 20 | Discuss the limitations of the scoping review process. | [5.11](http://127.0.0.1:10065/rmd_output/0/#item20) |
| Conclusions | 21 | Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps. | [5.12](http://127.0.0.1:10065/rmd_output/0/#item21) |
| **Funding** | | | |
| Funding | 22 | Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review. | [9](http://127.0.0.1:10065/rmd_output/0/#item22) |

11.4 Additional tables

Full descriptions of study characteristics are available in Table [11.4](http://127.0.0.1:10065/rmd_output/0/#tab:studychar).

| Table 11.4: Characteristics of included studies | | | |
| --- | --- | --- | --- |
| **Study** | **Country of origin** | **Sample characteristics** | **Sample size** |
| Ahn et al117 | Korea | Patients >55 years with insomnia disorders | 33 |
| Al Lawati et al6 | Oman | Healthy Omani nationals | 321 |
| Alameddine et al88 | USA | Participants referred to a sleep centre for PSG | 879 |
| Ansok et al118 | USA | Patients with rotator cuff tears | 18 |
| Argyropoulos et al119 | United Kingdom | Outpatients with moderate to severe depression, without psychotic features, in an RCT of two antidepressants | 40 |
| Aritake-Okada et al120 | Japan | Healthy males | 22 |
| Arora et al121 | United Kingdom | Adolescents aged 11-13 | 255 |
| Auger et al122 | USA | Patients referred to an academic sleep centre | 84 |
| Baek et al52 | Korea | Shiftwork nurses | 94 |
| Baillet et al5 | France | Older adults with no sleep disorders, sleep medications, or depressive symptomatology | 45 |
| Baker et al123 | South Africa | Healthy young subjects | 20 |
| Barbosa et al124 | Brazil | Visually impaired individuals and participants without visual impairment | 77 |
| Bastien et al125 | Canada | Individuals with chronic psychophysiological insomnia, paradoxical insomnia and good sleepers | 88 |
| Bean et al126 | New Zealand | Chronic pain patients | 47 |
| Bensen-Boakes et al127 | Australia | Participants with comborbid insomnia and OSA | 145 |
| Bian et al128 | China | Inpatients with schizophrenia | 148 |
| Bianchi et al129 | USA | Patients referred to a sleep centre | 312 |
| Bianchi et al93 | USA | Healthy subjects undergoing in-lab sleep experiment | 44 |
| Billings130 | USA | Firefighters | 24 |
| Bonnet & Moore92 | USA | Young adults | 12 |
| Broomfield & Espie131 | United Kingdom | Individuals complaining of sleep-onset insomnia | 34 |
| Brychta et al132 | Iceland | 15-year, then 17-year old students of the same cohort | 144 |
| Caia et al133 | Australia | Professional rugby league athletes | 63 |
| Campanini et al134 | Brazil | School teachers | 163 |
| Carter et al135 | USA | Collegiate athletes | 121 |
| Castelnovo et al136 | Switzerland | Patients with insomnia | 249 |
| Castillo et al137 | USA | Patients referred to a sleep centre for PSG | 405 |
| Cederberg et al138 | USA | Patients with multiple sclerosis | 49 |
| Chan et al139 | USA | Community dwelling older adults with insomnia | 62 |
| Chan et al53 | USA | Individuals with fibromyalgia and Insomnia | 223 |
| Chen et al140 | Taiwan | Individuals with osteoarthritis | 30 |
| Chervin & Guilleminault141 | USA | Patients referred to a sleep centre for an MSLT for suspected excessive daytime somnolence | 147 |
| Cho et al142 | Korea | Participants from the sleep heart health study | 2540 |
| Choi et al143 | Korea | Patients referred to a sleep centre for PSG in addition to healthy volunteers | 420 |
| Chou et al144 | USA | Cognitively normal and mildly impaired older adults | 293 |
| Chung et al145 | Korea | Outpatients with schizophrenia | 66 |
| Combertaldi & Rasch146 | Switzerland | Young healthy students | 24 |
| Conroy et al147 | USA | Individuals experiencing insomnia in recovery from alcohol dependence | 21 |
| Creti et al148 | Canada | Participants with chronic fatigue syndrome | 49 |
| Crönlein et al149 | Germany | Patients receiving CBT-I for insomnia | 92 |
| Currie et al150 | Canada | Individuals experiencing insomnia in recovery from alcohol dependence | 56 |
| Curtis et al151 | USA | Participants with fibromyalgia and insomnia | 199 |
| D’Aoust et al152 | USA | Informal caregivers of persons with dementia | 53 |
| Dautovich et al49 | USA | Older adults who nap habitually | 100 |
| De Francesco et al78 | United Kingdom | People with HIV and people without HIV matched on demographic variables | 461 |
| De Jaeger et al153 | Belgium | Failed back surgery syndrome (FBSS) patients treated with spinal cord stimulation | 19 |
| Dean et al154 | USA | Adults with inoperable non-small cell lung cancer | 26 |
| Devine et al155 | USA | Army Reserve Officers’ Training Corp Cadets | 286 |
| Dietch & Taylor156 | USA | Representative community-based normative sample | 80 |
| Dinapoli et al157 | Italy | Older adults with mild cognitive impairment and subsyndromal depression | 59 |
| Dittoni et al158 | Italy | Chronic primary insomnia patients | 66 |
| Dorrian et al159 | Australia | Commercial passenger airline pilots | 306 |
| Dorsey & Bootzin160 | USA | Undergraduate students | 31 |
| Downey & Bonnet161 | USA | Subjective insomniacs | 10 |
| Duarte et al162 | Brazil | Patients undergoing PSG for suspected sleep-disordered breathing | 727 |
| Duarte et al163 | Brazil | Individuals with sleep disorders and contrls | 2004 |
| Dunican et al164 | Australia | Judo athletes | 23 |
| Dzierzewski et al165 | USA | Older adults with insomnia | 159 |
| Edinger & Fins2 | USA | Outpatients with insomnia presenting to a sleep disorders centre | 173 |
| Espie et al26 | United Kingdom | Individuals with insomnia | 20 |
| Etain et al166 | France | Adults with bipolar disorder and healthy controls | 154 |
| Facco et al167 | USA | Nulliparous women enrolled in the first trimester of pregnancy | 752 |
| Feige et al168 | Germany | Insomnia patients and good sleeper controls | 100 |
| Feige et al169 | Germany | Individuals with paradoxical insomnia and good sleeper controls | 200 |
| Feng & Svetnik70 | United Kingdom | Primary insomnia patients | n/a |
| Fernandez-Mendoza et al170 | USA | Insomniacs and controls | 866 |
| Finan et al171 | USA | Participants with opioid use disorder | 55 |
| Franklin & Svanborg172 | Sweden | Individuals referred to sleep center for suspected OSA | 100 |
| Friedmann et al71 | Germany | Women with PTSD after childhood abuse, mentally healthy women with a history of child abuse, and nontraumatised mentally healthy women | 184 |
| Gaina et al173 | Japan | Healthy junior high school children | 42 |
| Ghadami et al174 | Iran | War veterans diagnosed with chronic PTSD | 32 |
| Gibson et al67 | Australia | Australian army recruits | 59 |
| Girschik et al64 | Australia | Women recruited from the community | 56 |
| Gonzalez et al175 | USA | Individuals with bipolar type I | 39 |
| Gooneratne et al176 | USA | Older adults with and without insomnia complaint | 200 |
| Goudman et al177 | Belgium | Patients with failed back surgery syndrome treated with spinal chord stimulation | 39 |
| Goulart et al178 | Brazil | Healthy males with normal sleep randomised to three experimental groups | 31 |
| Guedes et al69 | Brazil | Adolescents | 37 |
| Gökce et al179 | Germany | Young adults in Munich | 74 |
| Hall et al180 | USA | Women with PTSD secondary to interpersonal violence | 45 |
| Hanisch et al50 | USA | Prostate cancer patients undergoing androgen therapy | 60 |
| He et al181 | China | Adults participants subject to COVID-19 lockdown provisions in China | 70 |
| Heath et al182 | Australia | Adolescents | 385 |
| Herbert et al183 | United Kingdom | Individuals with insomnia symptoms | 42 |
| Hermans et al184 | Netherlands | Older adults involved in a double-blind crossover study with zopiclone and placebo | 46 |
| Hermans et al79 | Netherlands | Insomnia patients and healthy controls | 231 |
| Hermans et al185 | Netherlands | Older adults with and without insomnia | 41 |
| Hermans et al95 | Netherlands | Participants with insomnia on a waitlist for CBT-I | 31 |
| Herring et al186 | USA | Urban low-income pregnant women | 80 |
| Hita-Yañez et al187 | Spain | Patients with MCI and healthy elderly | 50 |
| Hodges et al188 | USA | Cocaine-dependent persons admitted to an inpatient research facility | 43 |
| Hoogerhoud et al189 | Netherlands | Patients receiving index or maintenance ECT for a depressive episode | 12 |
| Hsiao et al190 | Taiwan | Healthy young adults | 36 |
| Huang et al191 | China | Primary insomnia patients and healthy controls | 170 |
| Hughes et al192 | USA | Vulnerable older adults participating in a Veterans Administration Adult Day Health Care (ADHC) program | 59 |
| Hur et al193 | Canada | Patients with interstitial lung disease | 111 |
| Ihler et al194 | France, Norway | Individuals with bipolar disorder and healthy controls | 196 |
| Jackowska et al72 | United Kingdom | Women working at University College London and neighbouring institutions | 179 |
| Jackson et al76 | USA | Adults enrolled in a large longitudinal study | 1910 |
| Jackson et al77 | USA | African-American adults | 821 |
| Janků et al195 | Czech Republic | Insomnia patients | 36 |
| Jungquist et al196 | USA | Community-dwelling adults | 300 |
| Kang et al197 | USA | Individuals with major depressive disorder, individuals with primary insomnia, and normal sleeping controls | 82 |
| Kaplan et al198 | USA | Individuals with bipolar disorder and age and sex-matched controls | 54 |
| Kaufmann et al199 | USA | Individuals with bopolar disorder and healthy controls | 85 |
| Kawada200 | Japan | Healthy university students | 76 |
| Kay et al201 | USA | Individuals with paradoxical insomnia and good sleeper controls | 62 |
| Kay et al202 | USA | Older adults with and without insomnia | 114 |
| Kay et al73 | USA | Older adults with and without sleep complaint | 103 |
| Keklund & Akerstedt203 | Sweden | Individuals involved in a study of early morning work or a study of sleep in a truck-berth | 37 |
| Kennedy et al204 | Ireland | Patients with advanced chronic kidney disease or end-stage kidney disease | 54 |
| Khou et al205 | USA | Community dwelling older adults with and without mild Alzheimers disease | 86 |
| King et al206 | USA | Female undergraduates enrolled in an interior design programme | 28 |
| Kishikawa et al207 | Japan | Outpatients with primary insomnia undergoing CBT-I | 52 |
| Kobayashi et al208 | USA | Urban-residing African Americans with and without trauma exposure and PTSD | 103 |
| Kolling et al209 | Germany | German undergraduate and graduate physical education students | 72 |
| Kong et al210 | China | Children recruited from primary and secondary schools in Hong King | 133 |
| Krahn et al114 | USA | Psychiatric inpatients | 30 |
| Kreutz et al211 | Germany | Breast cancer patients starting neoadjuvant chemotherapy | 54 |
| Krishnamurthy et al212 | USA | Bipolar disorder patients and healthy controls similar in age, race, and sex | 54 |
| Kryger et al213 | Canada | Patients with chronic insomnia | 16 |
| Krystal & Edinger214 | USA | Patients with primary insomnia with sleep maintenance difficulty evident in subjective sleep measures | 30 |
| Krystal et al215 | USA | Individuals with subjective insomnia, objective insomnia and normal controls | 50 |
| Kundu et al216 | India | Individuals with chronic insomnia and obstructive sleep apnoea | 32 |
| Kung et al217 | Taiwan | Taiwanese adults with major depression | 30 |
| Lan Chun Yang et al218 | Canada | Participants diagnosed with mTBI/concussion | 37 |
| Laranjeira et al219 | Brazil | Individuals referred to a sleep centre | 248 |
| Lastella et al220 | Australia | Well-trained male soccer players | 12 |
| Lauderdale et al66 | USA | Young adults enrolled in the Coronary Artery Risk Development in Young Adults study | 647 |
| Lecci et al (study 2)221 | Switzerland | Insomnia patients and healthy subjects | 34 |
| Lecci et al221 | Switzerland | Population-based sample | 2092 |
| Lee et al222 | Korea | Patients with OSA | 707 |
| Lee et al223 | Korea | Adults with insomnia | 105 |
| Lee224 | United Kingdom | Adults aged 20 or above | 8438 |
| Lehrer et al94 | USA | Middle-aged community-dwelling women | 323 |
| Lewis60 | United Kingdom | Healthy young men | 8 |
| Lipinska & Thomas225 | South Africa | Women with PTSD, trauma exposure with no PTSD, and healthy controls | 60 |
| Liu et al226 | China | Patients diagnosed with OSA | 355 |
| Liu et al227 | China | Healthy young adults | 10 |
| Locihova et al228 | Czech Republic | Patients admitted to an intensive care unit of a hospital | 20 |
| Lockley et al48 | United Kingdom | Blind individuals | 49 |
| Lubas et al229 | USA | Participants enrolled in a longitudinal study of survivors of childhood cancer | 477 |
| Lund et al230 | USA | Older adults with comorbid insomnia | 60 |
| Ma et al231 | USA | Individuals with insomnia, insomnia & comorbid OSA, OSA only, and normal sleep controls | 638 |
| Maes et al232 | Belgium | Female patients diagnosed with primary insomnia and healthy female controls | 28 |
| Maich et al233 | Canada | Individuals with insomnia and good sleeper controls | 74 |
| Majer et al234 | USA | Individuals with chronic fatigue and non-fatigued controls | 75 |
| Manconi et al (study 2)235 | Italy | 159 patients with primary insomnia | 159 |
| Manconi et al235 | Italy, USA | Normal subjects | 288 |
| Maric et al236 | Switzerland | Healthy right-hand males | 14 |
| Martinez et al237 | Brazil | Patients referred to a university-affiliated sleep clinic for PSG | 5764 |
| Matousek et al238 | Czech Republic | Patients with minor depression, complaining of insomnia | 28 |
| Mazza et al239 | France | Children aged 8-9 years recruited from elementary schools | 76 |
| McCall & McCall240 | USA | Patients diagnosed with current major depressive episode and chronic insomnia | 54 |
| McCall et al241 | USA | Individuals undergoing PSG for suspected sleep apnoea | 84 |
| McIntyre et al55 | New Zealand | Healthy women late in third trimester | 30 |
| Means et al3 | USA | Middle-aged and older individuals with insomnia and matched normal sleepers | 101 |
| Mendelson et al74 | USA | Individuals with insomnia and age and sex matched controls | 20 |
| Mendelson242 | USA | Participants who complained of poor sleep | 8 |
| Mercer et al243 | USA | Individuals with insomnia and good sleepers | 22 |
| Meyer et al244 | United Kingdom | Outpatients with schizophrenia | 14 |
| Miner et al245 | USA | Community-dwelling older adults | 5835 |
| Moore et al246 | USA | 43 women with insomnia who had completed treatment for breast cancer | 43 |
| Most et al247 | Netherlands | Older adults with early and late stage alzheimers disease or healthy controls | 81 |
| Mundt et al248 | USA | Adults with insomnia and fibromyalgia randomised to CBT-I, CBT for pain, or waitlist control | 113 |
| Nam et al249 | Korea | Patients referred to a sleep clinic for evaluation of snoring/OSA | 50 |
| Narisawa et al250 | Japan | Participants with subjective sleep difficulty | 50 |
| Nazem et al251 | USA | Male veterans with traumatic brain injury | 19 |
| Neu et al56 | Belgium | Individuals with chronic fatigue and female controls | 40 |
| Nguyen-Michel et al51 | France | Older adults referred for insomnia complaints or suspected sleep apnoea | 135 |
| Normand et al252 | Canada | Paradoxical insomnia, psychophysiological insomnia, good sleepers | 70 |
| O’Brien et al253 | USA | Treatment-seeking overwieght/obese participants | 63 |
| Okifuji & Hare254 | USA | Patients with fibromyalgia | 75 |
| Okun et al255 | USA | Pregnant women | 104 |
| Orta et al256 | Chile | Female primary caregivers of children with disabilities | 175 |
| Ouellet & Morin257 | Canada | Patients with mild to severe traumatic brain injury and healthy good sleepers | 28 |
| Park et al258 | USA | Postmenopausal women | 384 |
| Perlis et al259 | USA | Female fibromyalgia patients | 20 |
| Perlis et al260 | USA | Individuals with primary insomnia, insomnia secondary to depression, and good sleeper controls | 27 |
| Pinto Jr et al261 | Brazil | Individuals selected from a university sleep laboratory | 199 |
| Provencher et al262 | Canada | Individuals with psychophysiological insomnia, paradoxical insomnia, and good sleepers | 67 |
| Reess et al263 | Germany | Patients with insomnia, sleep-related movement disorders (SMD), hypersomnia, and parasomnia | 159 |
| Regestein et al65 | USA | Healthy, postmenopausal women having hot flash activity | 88 |
| Richardson et al264 | Australia | Adolescents diagnosted with delayed sleep-wake phase disorder | 103 |
| Ritter et al265 | Germany | Euthymic outpatients with bipolar disorder and healthy volunteers | 50 |
| Rogers et al27 | USA | Patients with narcolepsy and matched controls | 50 |
| Saline et al96 | USA | Adult patients referred to a clinical sleep laboratory | 643 |
| Santos et al266 | Brazil | Participants in a longitudinal study | 2036 |
| Sato et al267 | Japan | Patients experiencing psychophysiological insomnia | 20 |
| Scarlett et al268 | Ireland | Community-dwelling older adults | 1520 |
| Schneider-Helmert & Kumar269 | Switzerland | Participants with primary insomnia | 128 |
| Schokman et al270 | Sri Lanka | Sri Lankan adults | 175 |
| Schulz & Walther271 | Germany | Individuals referred to a sleep centre for investigation of sleep disorders | 117 |
| Segura-Jimenez et al272 | Spain | Women with fibromyalgia and healthy controls | 198 |
| Sharkey et al273 | USA | Patients in a methadone maintenance therapy for opioid dependence | 62 |
| Sharman et al274 | United Kingdom | Healthy sleepers | 16 |
| Short et al275 | Australia | Adolescents | 385 |
| Signal et al276 | USA | Flight crew | 21 |
| Silva et al277 | USA | Participants over 40 | 2113 |
| Sinclair et al57 | Australia | Patients with traumatic brain injury and non-injured controls | 42 |
| Slightam et al278 | USA | Veterans with PTSD and demographically similar controls | 120 |
| Smagula et al279 | USA | Males | 2850 |
| So et al280 | USA | Prepubertal children | 55 |
| Somma et al281 | Italy | Participants with insomnia and community dwelling adults matched on demographic variables | 60 |
| Spielmanns et al282 | Germany | CPAP users | 26 |
| Spinweber et al283 | USA | Laboratory-qualified poor sleepers laboratory-disqualified poor sleepers who were male students at a naval school | 60 |
| Sprajcer et al284 | Australia | Healthy adult male on-call workers | 72 |
| St-Onge et al285 | USA | Multi-racial, multi-ethnic sample of adults | 113 |
| Stout et al286 | USA | Military veterans and active-duty service members, 17 with PTSD, 20 without PTSD | 37 |
| Sun-Suslow et al287 | USA | People with and without HIV | 94 |
| Takano et al288 | Belgium | Adults | 54 |
| Tang & Harvey (study 2)289 | United Kingdom | Healthy good sleepers | 93 |
| Tang & Harvey289 | United Kingdom | Healthy good sleepers | 54 |
| Tang & Harvey290 | Various | Individuals with primary insomnia | 48 |
| Tang et al (study 2)291 | United Kingdom | Patients with primary insomnia split into a clock-monitoring group and display unit-monitoring group | 38 |
| Tang et al291 | United Kingdom | Poor and good sleepers | 60 |
| Thun et al54 | Norway | University students | 166 |
| Thurman et al68 | USA | Healthy participants | 30 |
| Tomita et al292 | Japan | patients complaining of excessive daytime sleepiness | 28 |
| Topalidis et al293 | Various | Healthy participants | 21 |
| Trajanovic et al4 | Serbia, USA | Patients referred to a sleep clinic | 136 |
| Tremaine et al294 | Australia | Children aged 11-16 | 65 |
| Tremaine et al295 | Australia | Children and adolescents | 66 |
| Trimmel et al296 | Austria | Patients with a range of sleep disorders who underwent laboratory or ambulatory PSG | 303 |
| Trimmel et al296 | Austria | Patients referred to sleep clinic in a department of neurology | 303 |
| Tsuchiyama et al297 | Japan | Patients with major depression admitted to a psychiatric hospital | 23 |
| Usui et al298 | Japan | Older and younger adults | 39 |
| Valko et al299 | Switzerland | Patients referred to a sleep clinic for PSG | 3303 |
| Vallieres & Morin300 | Canada | Participants with chronic primary insomnia | 17 |
| Van Den Berg et al301 | Netherlands | Community-dwelling older adults | 969 |
| Vanable et al28 | USA | Patients referred to sleep clinic with various sleep disorders | 104 |
| Wang et al302 | Taiwan | Heart failure patients | 43 |
| Wang et al303 | Canada | Naval sailors | 66 |
| Werner et al304 | USA | Women with PTSD experiencing PTSD-related sleep disturbance | 51 |
| Williams et al305 | USA | Community-dwelling older adults | 142 |
| Wilson et al306 | Canada | Individuals experiencing insomnia associated with chronic musculoskeletal pain | 40 |
| Wilson et al307 | Australia | Women in third trimester and first trimester of pregnancy and non-pregnant women | 64 |
| Winer et al75 | USA | Cognitively normal older adults | 89 |
| Wolfson et al308 | USA | High school students | 302 |
| Xu et al309 | China | Young adults | 47 |
| Yamakita et al310 | Japan | School-aged children | 58 |
| Yeung et al311 | China | Individuals with insomnia undergoing placebo acupuncture | 86 |
| Yoon et al312 | Korea | Patients with insomnia | 150 |
| Zak et al313 | USA | Healthy premenopausal women | 71 |
| Zhu et al314 | USA | Adults with type II diabetes | 53 |
| Zinkhan et al315 | Germany | Participants recruited from the community | 100 |
| Zou et al316 | China | Insomnia disorder patients and well-matched healthy controls | 64 |
| te Lindert et al110 | Netherlands | Individuals with insomnia disorder and individuals without sleep complaints | 236 |

Full qualitative methodological details for actigraphy studies are available in Table [11.5](http://127.0.0.1:10065/rmd_output/0/#tab:bigacti).

| Table 11.5: Qualitative actigraphy characteristics | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Study** | **Actigraph device** | **Software** | **Algorithm** | **Algorithm reference** | **Rest interval definition** |
| 1 | Chou et al144 | Actiwatch 2 | Actiware | Actiware Low (20) | 31 | Not reported |
| 3 | Janků et al195 | MotionWatch 8 | MotionWare | MotionWare | CamNTech, UK | Event marker –> sleep diary |
| 4 | King et al206 | Actiwatch Spectrum Plus | not reported | Actiware Medium (40) | 31 | Not reported |
| 5 | Lehrer et al94 | Actiwatch AW64 | Actiware | Actiware Medium (40) | 31 | Informed by sleep diaries, decided by study staff |
| 7 | Segura-Jimenez et al272 | SenseWear Pro3 Armband | SenseWear Professional | SenseWear | 32 | Set intervals |
| 8 | Slightam et al278 | Actiwatch AW64 | Actiware | Actiware Medium (40) | 31 | Event markers –> activity, sleep diary |
| 10 | Williams et al305 | Actiwatch-L | Actiware-Sleep | Actiware (not reported) | 31 | Not reported |
| 11 | Al Lawati et al6 | SOMNOwatch plus | Domino Light | Domino Light | 33 | Manual scoring |
| 12 | Ansok et al118 | Actiwatch Spectrum Plus | not reported | Cole-Kripke | 34 | Event markers –> sleep diary |
| 14 | Auger et al122 | Actiwatch AW64 | Actiware | Kripke | 35 | Automated –> sleep diary |
| 15 | Baillet et al5 | MotionWatch 8 | MotionWare | MotionWare | CamNTech, UK | Event markers –> sleep diary |
| 18 | Billings130 | ActiGraph wGT3X-BT | ActiLife | Cole-Kripke | 34 | Sleep diary, inconsistenies reviewed with participant |
| 19 | Brychta et al132 | ActiGraph GT3X+ | ActiLife | Sadeh | 36 | Visual inspection, sleep diaries |
| 20 | Cederberg et al138 | ActiGraph GT3X+ | ActiLife | Cole-Kripke | 34 | Sleep diary |
| 21 | Chan et al53 | Actiwatch 2 | not reported | not reported |  | Complex criteria involving sleep diary, activity levels, light |
| 25 | Currie et al150 | Mini Motionlogger | not reported | Cole-Kripke | 34 | Event marker |
| 26 | Dietch & Taylor156 | Actiwatch Spectrum | Actiware | Actiware Low (10) | 31 | Event markers –> sleep diaries –> activity/light patterns |
| 28 | Dunican et al164 | not reported | Readiband Sync | not reported |  | Not reported |
| 29 | Facco et al167 | not reported | not reported | Actiware Medium (40) | 31 | Not reported |
| 32 | Ghadami et al174 | not reported | not reported | not reported |  | Not reported |
| 33 | Girschik et al64 | Actiwatch Spectrum | Actiware | Actiware Medium (40) | 31 | Event marker –> sleep diary |
| 36 | Herring et al186 | Actiwatch AW64 | Actiware | Actiware (not reported) | 31 | Event markers –> sleep diary |
| 37 | Hoogerhoud et al189 | not reported | not reported | Actiware (not reported) | 31 | Not reported |
| 38 | Ihler et al194 | Actiwatch AW7 | Actiwatch activity & sleep analysis | Actiware (not reported) | 31 | Event markers |
| 39 | Jackowska et al72 | Actiheart monitor | Actiheart | Actiheart | 37 | Sleep logs; heart rate; activity |
| 41 | Kaplan et al198 | Actiwatch AW64 | Actiware | Actiware (Low, Medium, High) | 31 | Set to lights off and lights-on from PSG |
| 42 | Kawada200 | Actiwatch | not reported | Actiware Medium (40) | 31 | Not reported |
| 43 | Kay et al202 | Actiwatch 2 | Actiware | Actiware Medium (40), Cole-Kripke | 31;34 | Event marker; sleep diary; activity; light |
| 44 | Kay et al73 | Actiwatch-L | not reported | Actiware High (80) | 31 | Not reported |
| 47 | Khou et al205 | ActiGraph GT3X+ | ActiLife | Cole-Kripke | 34 | Self-report sleep logs compared against ActiLife defined bed and wake times, lux, movement data. If self-report within 30mins of actilife–interval set to self-report, if missing or invalid, ActiLife defined interval used |
| 48 | Kong et al210 | not reported | not reported | not reported |  | Not reported |
| 49 | Krahn et al114 | not reported | not reported | Cole-Kripke | 34 | Scored manually (tech was blinded to sleep diary) |
| 52 | Liu et al227 | Fitbit Alta | Fitbit software | Fitbit | 86 | Automatic (heart rate + activity) |
| 53 | Lockley et al48 | Motionlogger, Mini Motionlogger | Action 3 | not reported |  | Sleep diaries |
| 58 | Mazza et al239 | Actiwatch 2 | Actiware | Actiware Medium (40) | 31 | Event marker, activity, light |
| 61 | Moore et al246 | Actiwatch 2 | Actiware | Actiware Medium (40) | 31 | Not reported |
| 62 | Most et al247 | Actiwatch | Actiware | Actiware (not reported) | 31 | Vinyl-covered pressure sensitive pad and light-dependent resistor |
| 63 | Mundt et al248 | Actiwatch 2 | Actiware | Actiware High (80) | 31 | Sleep diaries |
| 65 | Nazem et al251 | Actiwatch 2 | Actiware | Actiware (not reported) | 31 | Not reported |
| 67 | Okifuji & Hare254 | Micro Mini Motionlogger | Action | not reported |  | Not reported |
| 68 | Orta et al256 | ActiSleep | ActiLife | Cole-Kripke | 34 | Not reported |
| 71 | Regestein et al65 | not reported | not reported | Actiware Medium (40) | 31 | Sleep diary |
| 72 | Ritter et al265 | SOMNOWatch Plus | Domino Light | Cole-Kripke | 34 | Event markers |
| 74 | Sato et al267 | not reported | not reported | Cole-Kripke | 34 | Not reported |
| 76 | Sharman et al274 | Actiwatch AW4 | Actiwatch Activity and Sleep Analysis | Actiware Medium (40) | 31 | Event markers –> sleep diary, verification from audio file timestamps |
| 78 | Spielmanns et al282 | PAM Polar A300 | not reported | not reported |  | N/a |
| 82 | Wang et al303 | Micro Motionlogger | Action 4 | not reported |  | Event markers |
| 83 | Werner et al304 | not reported | Action W | UCSD | 38 | Automatic |
| 87 | Barbosa et al124 | ActiGraph GT3X+ | ActiLife | Cole-Kripke | 34 | Sleep diary, activity, light |
| 90 | Broomfield & Espie131 | Actiwatch 2 | not reported | not reported |  | Event markers |
| 91 | Caia et al133 | Actiwatch 2, ActiGraph GT3X+, Readiband | not reported | not reported |  | Not reported |
| 92 | Campanini et al134 | Actiwatch 2 | Actiware | Actiware Medium (40) | 31 | Algorithms supplemented by event marker |
| 93 | Carter et al135 | Actiwatch Spectrum Pro | not reported | Actiware Medium (40) | 31 | Light |
| 97 | Chung et al145 | Actiwatch 2 | Actiware | Actiware Medium (40) | 31 | Event marker or sleep diary |
| 98 | Dautovich et al49 | Actiwatch-L | Actiware-Sleep | Actiware High (80) | 31 | Naps identified in sleep diaries, Webster’s rules (daily sleep logs, notes, illumination channel) |
| 99 | De Jaeger et al153 | Actiwatch Spectrum Plus | Actiware | Actiware (not reported) | 31 | Not reported |
| 100 | Dean et al154 | Octagonal Sleep Watch | Action 3 | not reported |  | Sleep diary |
| 104 | Gonzalez et al175 | Motionlogger | Action | UCSD | 38 | Not reported |
| 105 | Goudman et al177 | Actiwatch Spectrum Plus | Actiware | Actiware (not reported) | 31 | Not reported |
| 107 | Hanisch et al50 | Actiwatch AW64 | Actiware-Sleep | Actiware (not reported) | 31 | Sleep diary |
| 111 | Hughes et al192 | Actiwatch Spectrum | not reported | Actiware Medium (40) | 31 | Not reported |
| 112 | Kaufmann et al199 | Actisleep-BT | not reported | not reported |  | Not reported |
| 113 | Kreutz et al211 | ActiGraph wGT3X-BT | ActiLife | Cole-Kripke, Tudor-Locke | 34;45 | Tudor-Locke algorithm |
| 114 | Krishnamurthy et al212 | not reported | ActiLife | ActiLife | 39 | Not reported |
| 118 | Lauderdale et al66 | Actiwatch AW16 | not reported | not reported |  | Event markers –> sleep log |
| 119 | Lubas et al229 | Motionlogger | not reported | not reported |  | Event markers |
| 120 | Maich et al233 | Actiwatch Score | Mini-Mitter Actiwatch Software | Actiware Low (20) | 31 | Not reported |
| 126 | Okun et al255 | Actiwatch | Actiware | Actiware Medium (40) | 31 | Autointerval option with event markers |
| 127 | Park et al258 | Actillume I | Actillume Algorithm | Actillume | 38 | Sleep diary, notes, light, Webster’s rules |
| 131 | Scarlett et al268 | GENEactiv | GENEactive | Micro-Electro-Mechanical Systems | 40 | N/a |
| 132 | Schokman et al270 | Actiwatch Spectrum Pro | Actiware | Actiware Medium (40) | 31 | Manual: visual inspection, sleep diary entry, Actiwatch timestamps (according to neurosleep manual) |
| 133 | Stout et al286 | Micro Sleep Watch | not reported | not reported |  | Not reported |
| 134 | Tang & Harvey289 | Mini Motionlogger Basic | not reported | Cole-Kripke, Webster’s rescoring rules | 34 | Defined in-lab |
| 135 | Thun et al54 | Actiwatch AW7 | Actiwatch Activity and Sleep Analysis | Actiware Medium (40) | 31 | Not reported |
| 136 | Tomita et al292 | MicroMini RC | Action W2 | not reported |  | Manually corrected, using diaries where necessary |
| 137 | Tremaine et al295 | not reported | Actiware-Sleep | Actiware Medium (40) | 31 | Not reported |
| 139 | Usui et al298 | Motionlogger | not reported | Cole-Kripke | 34 | N/a |
| 142 | Wilson et al306 | Mini Motionlogger | not reported | Cole-Kripke, Webster’s rescoring rules | 34 | Not reported |
| 143 | Wolfson et al308 | Mini Motionlogger | Action W2 | Sadeh | 36 | Sleep diary |
| 144 | Yamakita et al310 | Lifecorder | Sleep Sign Act | Sleep Sign Act | Kissei Comtec Co, Japan | Set manually |
| 145 | Yeung et al311 | Actiwatch 2 | Actiware, Action W | Actiware (not reported) | 31 | Not reported |
| 148 | Baek et al52 | Actiwatch Spectrum Pro | Actiware | Actiware Medium (40) | 31 | Sleep diary |
| 149 | Chan et al139 | Actiwatch-L | Actiware-Sleep | Actiware Medium (40) | 31 | Sleep diary |
| 150 | Chen et al140 | not reported | not reported | not reported |  | Not reported |
| 154 | Heath et al182 | Micro Mini Motionlogger | Action W2 | Sadeh | 36 | Not reported |
| 156 | Kobayashi et al208 | Mini Motionlogger | Action W2 | Sadeh | 36 | Sleep diary, habitual sleep questionnaire |
| 157 | McCall & McCall240 | Actiwatch AW64 | Actiware | Actiware Medium (40) | 31 | Not reported |
| 159 | Vallieres & Morin300 | IM Systems Actigraph | Individual Monitoring Systems | IM Systems | Individual Monitoring Systems, Inc., USA | Not reported |
| 160 | Zhu et al314 | ActiGraph wGT3X | ActiLife | Actiware Medium (40), Cole-Kripke | 31;34 | Not reported |
| 161 | Hall et al180 | Motionlogger Basic | Action W | UCSD | 38 | N/a |
| 163 | Kolling et al209 | SenseWear MF Armband | SenseWear Professional | SenseWear | 32 | Event marker –> activity |
| 164 | Locihova et al228 | ActiGraph wGT3X-BT | ActiLife | Cole-Kripke | 34 | Externally defined |
| 167 | Winer et al75 | Micro Motionlogger | Action W2 | Sadeh | 36 | Sleep diary and event markers |
| 168 | D’Aoust et al152 | Actiwatch-L | Actiware | Actiware (not reported) | 31 | Sleep diary |
| 169 | Dinapoli et al157 | SenseWear MF Armband | SenseWear | SenseWear | 32 | Not reported |
| 170 | Dorrian et al159 | not reported | Actiware-Sleep | Actiware Medium (40) | 31 | Not reported |
| 173 | O’Brien et al253 | Motionlogger Basic | Action W | Sadeh | 36 | Sleep diary, discrepancies queried |
| 174 | St-Onge et al285 | ActiGraph GT3X+ | not reported | not reported |  | Not reported |
| 176 | Arora et al121 | ActiGraph GT3X+ | not reported | not reported |  | Sleep diary |
| 180 | Curtis et al151 | Actiwatch 2 | Actiware | Actiware (not reported) | 31 | Sleep diary |
| 181 | Devine et al155 | Actiwatch 2 | Actiware | Actiware Medium (40) | 31 | Automatically defined, sleep diary/ other daily schedule info |
| 183 | Dzierzewski et al165 | Actiwatch Spectrum | not reported | Actiware (not reported) | 31 | Not reported |
| 184 | Etain et al166 | Actiwatch AW7 | Actiwatch Activity and Sleep Analysis | Actiware (not reported) | 31 | Sleep diary and event markers |
| 186 | Gibson et al67 | ActiGraph GT9X Link | ActiLife | Cole-Kripke | 34 | Externally defined (platoon sleep record) |
| 187 | Gökce et al179 | ActiGraph wGT3X-BT | Actiware | Cole-Kripke | 34 | Software-defined |
| 188 | Herbert et al183 | MotionWatch 8 | MotionWare | Sadeh | 36 | Sleep diary |
| 191 | Jackson et al76 | Actiwatch Spectrum | Actiware-Sleep | Actiware (not reported) | 31 | Event marker, sleep diary, light sensor |
| 193 | Kung et al217 | Mini Motionlogger | Action W2 | not reported |  | Externally-defined (lights on/off times at psychiatric ward) |
| 196 | Lee224 | ActiGraph GT3X+ | not reported | Machine learning algorithm | 41 | Not reported |
| 199 | Meyer et al244 | Fitbit Charge HR | Sleepsight | Fitbit | 86 | N/a |
| 200 | Kishikawa et al207 | Actiwatch 2 | Actiware | Actiware Medium (40), Cole-Kripke | 31;34 | Event markers |
| 201 | Santos et al266 | Actiwatch 2 | not reported | not reported |  | Event marker |
| 203 | Smagula et al279 | SleepWatch-O | Action W2 | Cole-Kripke, UCSD | 34;38 | Sleep diary –> manual scoring |
| 204 | te Lindert et al110 | GENEactiv | GENEactive | Actiware (Low, Medium, High) | 31 | Sleep diary |
| 205 | Thurman et al68 | Readiband Actigraph SBV2 | Fatigue Science Software | Fatigue Science | 42 | Sleep offset/onset defined by sleep state (9pm-11am) |
| 206 | Topalidis et al293 | Xiaomi Mi Band 3, GT3X ActiGraph | ActiLife | Cole-Kripke | 34 | N/a |
| 207 | Van Den Berg et al301 | Actiwatch AW4 | Actiware | Actiware Low (20) | 31 | Event marker –> sleep diary |
| 208 | Zak et al313 | Mini Motionlogger, Actigraph Model AAM-32 | Action | Cole-Kripke | 34 | Event marker |
| 209 | De Francesco et al78 | ActiGraph wGT3X-BT | not reported | not reported |  | Not reported |
| 210 | Gaina et al173 | Actiwatch | not reported | not reported |  | Sleep diary |
| 211 | Guedes et al69 | Mini Motionlogger Basic | Action W2 | Sadeh | 36 | Sleep/activity log |
| 213 | Sinclair et al57 | not reported | Actiware | Actiware Medium (40) | 31 | Sleep diary |
| 214 | Takano et al288 | ActiGraph wGT3X-BT | Actiware | Cole-Kripke | 34 | Unsure/ not reported |
| 215 | Tang et al291 | Mini Motionlogger Basic | Action W | Cole-Kripke | 34 | Webster’s rules (daily sleep logs, notes, illumination channel) |
| 216 | Tang & Harvey290 | Mini Motionlogger Basic | Action W | Cole-Kripke | 34 | Webster’s rules (daily sleep logs, notes, illumination channel) |
| 217 | Wang et al302 | Motionlogger | Action W2 | not reported |  | Not reported |
| 219 | Creti et al148 | Actitrac | IM Systems Software | IM Systems | Individual Monitoring Systems, Inc., USA | Externally set (PSG) |
| 222 | He et al181 | ActiGraph wGT3X-BT | ActiLife | Cole-Kripke, Choi, Troiano | 34;44;46 | N/a or not reported |
| 223 | Hur et al193 | ActiGraph wGT3X-BT | ActiLife | Cole-Kripke | 34 | Sleep diaries |
| 224 | Jungquist et al196 | Camntech Pro-Diary | MotionWare | MotionWare | CamNTech, UK | Not reported |
| 230 | Short et al275 | Motionlogger | Action W2 | Sadeh | 36 | Sleep diary |
| 231 | So et al280 | Micro Motionlogger | not reported | Sadeh | 36 | Event marker |
| 233 | Sun-Suslow et al287 | ActiGraph GT9X Link | not reported | Cole-Kripke | 34 | Sleep diary –> manual |
| 234 | Tremaine et al294 | not reported | Actiware-Sleep | Actiware Medium (40) | 31 | Sleep diary |
| 235 | Jackson et al77 | ActiGraph GT3X+ | ActiLife | Cole-Kripke | 34 | Manual: sleep diary, activity, light |
| 237 | Bean et al126 | Actiwatch AW64 | Cambridge Neurotechnology Sleep Analysis 5.5 | Actiware (not reported) | 31 | Sleep diary |
| 238 | Miner et al245 | SleepWatch-O | Action W2 | UCSD | 38 | Software and sleep diaries |
| 239 | Richardson et al264 | Micro Mini Motionlogger | not reported | Sadeh | 36 | Manual and sleep diary |
| 241 | Friedmann et al71 | Move II | not reported | Barouni | 43 | Sleep onset during fixed interval: 20:00-00:00 |
| 243 | Signal et al276 | Actiwatch | Actiware-Sleep | Actiware (Low, Medium, High) | 31 | Event marker, sleep diary |
| 244 | Narisawa et al250 | Actiwatch | not reported | not reported |  | Activity levels |
| 245 | Tang & Harvey (study 2)289 | Mini Motionlogger Basic | not reported | Cole-Kripke | 34 | Defined in-lab |
| 248 | Tang et al (study 2)291 | Mini Motionlogger Basic | Action W | Cole-Kripke | 34 | Webster’s rules (daily sleep logs, notes, illumination channel) |
| *Note:*The –> arrow designates the priority given to methods of calculating the rest interval. For example, event markers –> activity, sleep diary, indicates that event marker presses were first used to calculate rest intervals, followed by sleep diary and activity when event marker presses were not available. | | | | | | |

A full list of studies that recorded sleep-wake agreement is available in Table [11.6](http://127.0.0.1:10065/rmd_output/0/#tab:sleepwake) below.

| Table 11.6: Direct sleep-wake agreement studies | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | **Study** | **Sample characteristics** | **Sleep variables** | **Sleep-wake agreement type** | **PSG setting** |
| 60 | Mendelson et al74 | individuals with insomnia and age and sex matched controls | TST, sleep after experimental awakenings, awake/asleep upon awakening (binary) | Binary | in-lab |
| 73 | Rogers et al27 | patients with narcolepsy and matched controls | Sleep/wake agreement (15-minute blocks), 3 time periods (spanning 24hr) transition (lights on/off), sleep period, daytime | Confusion matrix | home-based |
| 101 | Dorsey & Bootzin160 | undergraduate students | SOL (MSLT), sleep / wake agreement [Terminal sleep stage at each sleep latency test (objective), estimated conscious state by subject (subjective)] | Confusion matrix | in-lab |
| 123 | Mendelson242 | participants who complained of poor sleep | Participant report of having been awake/asleep following experimental awakenings | Binary | in-lab |
| 124 | Mercer et al243 | individuals with insomnia and good sleepers | home PSG: TST, SOL, WASO, SE; lab: signal detection for PSG-wake as signal (exp awakenings), TST, sleep between probes | Binary | in-lab, home-based |
| 139 | Usui et al298 | older and younger adults | sleep/ wake agreement, 10-minute epochs | Confusion matrix | n/a |
| 152 | Downey & Bonnet161 | subjective insomniacs | SOL, participant sleep/wake judgement following experimental awakenings | Binary | in-lab |
| 165 | Nguyen-Michel et al51 | older adults referred for insomnia complaints or suspected sleep apnoea | Perception of sleep during nap (binary) | Binary | in-lab |
| 170 | Dorrian et al159 | commercial passenger airline pilots | TST; sleep/wake | Confusion matrix | n/a |
| 229 | Schulz & Walther271 | individuals referred to a sleep centre for investigation of sleep disorders | sleep / wake judgement following induced awakenings | Binary | in-lab |
| *Note:*Binary sleep-wake involved measuring at one or multiple instances whether a participant’s reported sleep state matched the objective sleep state upon which the query was conditional (e.g., participants were only queried during objectively-confirmed sleep). On the other hand, confusion matrix sleep-wake involved measuring at one or multiple instances whether a participant’s reported sleep state matched an objective sleep state that was allowed to vary independent of the query (e.g., participants were queried at a certain time point irrespective of sleep state). The states were called so as the former approach produces a binary outcome whereas the latter produces a confusion matrix. | | | | | |

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