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REVIEW ARTICLE

The importance and limitations of polysomnography in insomnia disorder—a critical appraisal

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Summary

The importance polysomnography (PSG) in the diagnosis and treatment process of insomnia disorder (ID) remains highly disputed. This review summarises the state of the science regarding PSG indications and findings in ID, and the indications to conduct PSG in ID as stated by relevant guidelines. It then highlights the most relevant questions regarding the topic, including the relevance of ID subtyping, to allow an individualised pharmacological or psychotherapeutic treatment approach.

KEYWORDS
individualised care, objective, PSG, recommendation

1 | INTRODUCTION

In the history of insomnia disorder (ID), different conceptualisations of the disorder have been proposed. They either emphasised adjustment to external factors, psychophysiological interactions, misperception of somatic functions, (cognitive or somatic) hyperarousal, or categorically differentiated between organic or non-organic insomnia in their pathophysiological hypothesis. Notwithstanding these different concepts, the question whether or not a form of ID was diagnosed predominately relied on subjective complaints. To date, the importance of objective sleep measurements and especially the significance of polysomnography (PSG) in the diagnosis and treatment process of ID remains highly disputed. The following review summarises the state of the science regarding PSG indications and findings in ID and highlights the most relevant scientific questions regarding the topic.

2 | POLYSOMNOGRAPHY – THE 'GOLD STANDARD' IN SLEEP DIAGNOSTICS?

Polysomnography as a technique was developed to enable a complete and objective assessment of sleep and most sleep-related phenomena. PSG is internationally conducted according to criteria defined by the American Academy of Sleep Medicine (AASM; Berry et al., 2015). The AASM guideline specifies set-up and measurements based on an ongoing consensus process. PSG data includes electroencephalography (EEG), electrocardiography, electro-oculography, electromyography, oximetry, airflow sensors, plethysmography, microphones, and infrared video recording among others. The term PSG reflects the multitude of measurements. Using these data, qualified specialists score each epoch of time (usually 30 s) into one of the five sleep stages and additionally score other events such as eye movement density in rapid eye movement (REM) sleep, breathing events (sleep-disordered breathing

[SDB], e.g., hypopneas and apneas), periodic leg movements during sleep (PLMS), and also note behavioural abnormalities (e.g., parasomnias). Software then computes defined parameters on sleep quantity (e.g., total sleep time, sleep onset latency) and sleep architecture (e.g., amount of time spent in a specific sleep stage) as well as on the frequency of sleep-related phenomena such as SDB, PLMS or behavioural abnormalities (e.g., parasomnias). Many specific sleep disorders such as narcolepsy (Ruoff & Rye, 2016) or REM sleep behaviour disorder (Högl et al., 2022; Riemann et al., 2017) require the conductance of PSG for diagnosis.

The diagnostic pathway in ID significantly differs from this approach. Insomnia is defined as a subjective sleep continuity disturbance with daytime impairments (Perlis et al., 2022). Sleep continuity, as a concept, comprises sleep onset latency, number of nocturnal awakenings, wake time after sleep onset (WASO), early morning awakening, as well as total sleep time and sleep efficiency. Related daytime impairment includes sleepiness, fatigue, somatic symptoms, mood disturbances and cognitive or occupational disturbances. The current fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013), defines ID as a predominant sleep continuity impairment at least 3 nights/week despite adequate opportunity for sleep, and with significant daytime impairment. The symptoms should not be better explainable by another condition or substance use, but comorbid disorders with overlapping symptoms can be diagnosed. Symptom duration can be used to differentiate between acute and chronic (>3 months) insomnia. The 11th revision of the International Classification of Diseases (ICD-11 World Health Organization, 2019) mostly follows the same approach but does not quantify the symptom frequency. Remarkably, ID is defined in all relevant diagnostic frameworks by subjective complaints without any need for objective sleep measurements including PSG (DSM-5; *International Classification of Sleep Disorders*, third edition; ICD-11).

3 | POLYSOMNOGRAPHY RESULTS AND RECOMMENDATIONS IN INSOMNIA DISORDER

Despite not being fundamental in the clinical/diagnostic pathway, a broad base of PSG data from patients with ID has been published. A meta-analysis by Baglioni et al. (2014) summarises the main findings: during 8 h of standardised PSG recording, patients with ID regularly display a significant reduction of total sleep time (24 min), a significantly longer sleep onset duration (increased by ~6 min), and more frequent nocturnal awakenings (~6 awakenings more) (Baglioni et al., 2014). Regarding sleep architecture, PSG detected 20 min less slow wave sleep and 11 min less REM sleep in patients with ID compared to good sleeping controls (GSC), corresponding to an increase of ~22 min of WASO (Baglioni et al., 2014). These significant objective discrepancies between patients with ID and GSC can be found in large population samples, but historically fail to be a robust diagnostic marker for the clinical complaint of insomnia and the diagnosis of ID. This phenomenon has been explained by a typical high level of discrepancy between subjective and objective measurements of sleep (Benz et al., 2023). In addition, PSG findings are significant, but rather small in effect size and fail to adequately represent the distinct reduction in the quality-of-life patients are experiencing (Perlis et al., 2022).

Figure 1 shows exemplary recordings of patients with ID displaying no objective sleep disturbances (a) or a strong reduction of sleep efficiency and continuity (b).

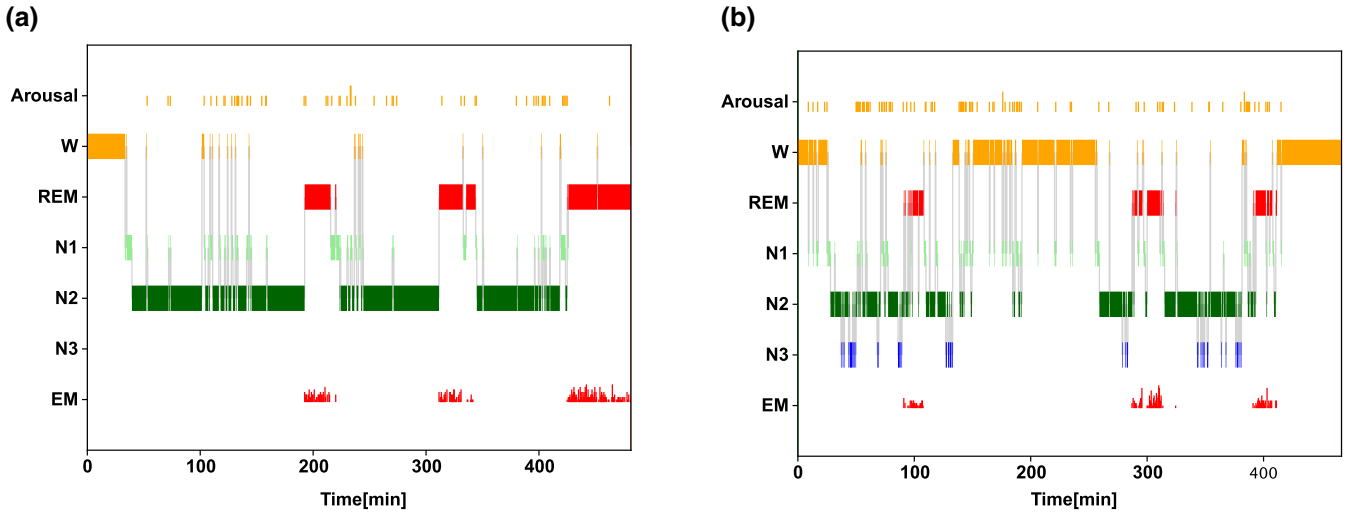

FIGURE 1 Span of potential polysomnography results in insomnia disorder (ID). (a) ID without objective sleep continuity disturbance. The hypnogram displays a good sleep efficiency of 89%. Even though minor findings include a slight elongation of sleep onset latency and lacking N3 sleep, these findings are unspecific and common. Typically, a normal hypnogram in patients with ID can be accompanied by strong subjective complaints about a reduced sleep time ('subjective–objective discrepancy'). (b) ID with objective sleep continuity disturbance. The hypnogram displays a clear sleep continuity reduction with increased wake time after sleep onset and reduced total sleep time and efficiency (59%). W, wake time; REM, time in rapid eye movement sleep; N1, time in non-REM sleep Stage 1; N2, time in non-REM sleep Stage 2; N3, time in non-REM sleep Stage 3; EM, eye movements. Data from the Psychiatric Sleep Laboratory, Department of Psychiatry and Psychotherapy, Medical Center, University of Freiburg. [Color figure can be viewed at wileyonlinelibrary.com]

One approach to potentially improve this dilemma is to implement finer grained examination techniques such as sleep EEG spectral analysis (Zhao et al., 2021), detection of micro-arousals and cyclic alternating patterns (Dikeos et al., 2023) or evaluation of responsiveness by inducing event-related potentials during PSG recorded sleep (Feige et al., 2021). In summary, the studies support the concept of a continuous hyperarousal in patients with ID (Dressle & Riemann, 2023) and introduce newer potential biological signatures of ID including REM-sleep quality and stability (Feige et al., 2018). Figure 2 displays micro sleep architecture differences between GSC and patients with ID. However, all of these newer approaches should be considered as research tools and, to date, are not validated for clinical purposes for example diagnosing ID.

After evaluation of these considerations, a recent consensus statement by a task force of the World Federation of Societies of Biological Psychiatry (WFSBP) on biomarkers in ID concludes that the usefulness of general PSG in the diagnostic of ID remains low and weakly supported by the literature, but some PSG-derived parameters might have potential for future applications (Dikeos et al., 2023).

In the last decade, comorbid insomnia and sleep apnea, coined as 'COMISA' (Sweetman et al., 2019), has become a focus of many researchers and clinicians. To date, a SDB prevalence of ~30% is described for patients with ID, with ~30% of patients with SDB also fulfilling diagnostic criteria of ID (Sweetman et al., 2019). Due to this high and very relevant overlap, objective sleep diagnostics including PSG might be of greater importance for patients with ID than expected by evaluating ID alone.

Based on the referenced findings and considerations, the 'Clinical guideline for the evaluation and management of chronic insomnia in adults' by the AASM recommends no routine PSG for patients with (chronic) insomnia (Schutte-Rodin et al., 2008). It then specifies cases in which PSG should be conducted: cases with reasonable clinical suspicion of SDB, PLMS or violent or injurious parasomnias, and when ID diagnosis is uncertain or treatment resistant (Schutte-Rodin et al., 2008). The 'European guideline for the diagnosis and treatment of insomnia' by the European Sleep Research Society (ESRS) also recommends PSG mostly to rule out other sleep disorders (e.g., PLMD, SDB) in cases of clinical suspicion of such or treatment-resistant insomnia (Riemann et al., 2017). In addition, occupational at-risk groups (e.g., professional drivers) might warrant a higher diagnostic safety as provided by PSG. An additional positive PSG recommendation refers to cases with an assumed large discrepancy between subjectively experienced and objectively measured sleep (Schutte-Rodin et al., 2008).

4 | THE PHARMACOLOGICAL PERSPECTIVE

As stated, ID is not defined by objective sleep disturbances measured by PSG. In stark contrast, clinical trials trying to establish the efficacy of novel drugs for the treatment of ID still predominantly define PSG changes during treatment as the main outcome criteria (Mignot et al., 2022). It remains an unclear, but self-evident conclusion whether only patients with ID that display these objective sleep disturbances, should be expected to respond to pharmacotherapy. The discussion is related to the question of potential subtypes of ID with short objective sleep duration being one of the most promising parameters to define a clinical subtype (Fernandez-Mendoza, 2017;

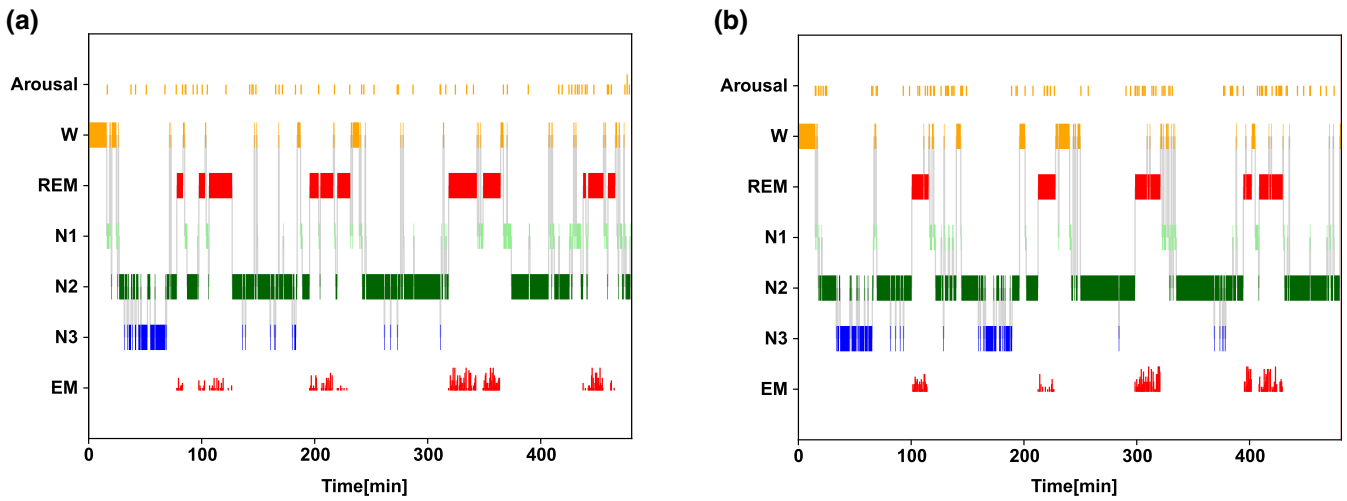

FIGURE 2 Micro-sleep architecture changes in insomnia disorder (ID). (a) Good sleeping controls (GSC) without objective sleep continuity disturbance. Even in GSC, the hypnogram typically reveals some level of minor sleep discontinuity. In this case, a sleep efficiency of 88% would be considered normal and was accompanied by 5.3 arousal reactions/h of rapid eye movement (REM) sleep. (b) ID without major objective sleep continuity disturbance but with pronounced REM sleep related arousal. While the hypnogram displays no major sleep continuity disturbance, further analysis shows an increased index of REM sleep-related arousals (26.0 arousal reactions/h), which can often be found in patients with ID. The clinical implication of this finding remains unclear. W, wake time; REM, time in rapid eye movement sleep; N1, time in non-REM sleep Stage 1; N2, time in non-REM sleep Stage 2; N3, time in non-REM sleep Stage 3; EM, eye movements. Data from the Psychiatric Sleep Laboratory, Department of Psychiatry and Psychotherapy, Medical Center, University of Freiburg. [Color figure can be viewed at wileyonlinelibrary.com]

Kao et al., 2021; Miller et al., 2016; Vgontzas et al., 2013). Patients with ID with shorter sleep duration appear more biologically affected and show stronger signs of hyperarousal, cardiometabolic and neurocognitive impairment (Vgontzas et al., 2013). As the available pharmacological approaches target different pathways of arousal regulation (Frase et al., 2018), PSG-guided decision making regarding when and which agent to use appears promising.

However, other ways of describing subtypes of ID including history assessment (Blanken et al., 2019), genetics (Stein et al., 2018) and multivariate approaches (Benjamins et al., 2017) have been proposed and a clear consensus on the validity of the proposed subtypes has not been reached (Perlis et al., 2022; Riemann et al., 2022). In addition, clinical studies to support the hypothesis of PSG-guided decision making when considering pharmacotherapy are lacking.

5 | THE PSYCHOTHERAPEUTIC PERSPECTIVE

Patients with ID typically display a pronounced discrepancy between objective, PSG-derived sleep parameters and the respective subjective reports (Benz et al., 2023). It has been proposed that the value of this discrepancy can be used to identify another specific 'sleep misperception' ID subtype (Edinger & Krystal, 2003). This subtype was speculated to be more responsive to cognitive behavioural therapy for insomnia (CBT-I), with feedback on the amount of the subjective–objective discrepancy, which relies on PSG recordings, as a significant component (Tang & Harvey, 2004). However, while CBT-I typically decreases subjective–objective discrepancy (Crönlein et al., 2019; Janků et al., 2020; Kay et al., 2015; Nishikawa et al., 2021), neither the initial amount of discrepancy nor explicitly giving feedback to patients about it significantly impacted overall CBT-I treatment response (Janků et al., 2020).

In the treatment of other neuropsychological disorders, such as chronic pain syndrome, much broader research has been directed at the importance of patients' expectancy for unspecific (placebo/nocebo) effects (Benedetti et al., 2003). As patients with ID often display very strong sleep-related expectancies and dysfunctional beliefs (Ballot et al., 2021), it is worth discussing how clinicians should react to strong beliefs about the amount and importance of the assumed objective sleep disturbance. PSG can fulfil the expectancy to get 'thoroughly examined' and reassure about the robustness of human sleep physiology. Whether this effect warrants the cost of PSG remains an open question.

6 | THE SCIENTIFIC PERSPECTIVE

Although significant amounts of data on PSG in ID has been published, many factors remain unclear. The following list references some of the most urgent research questions on PSG in insomnia:

- Long-term examinations on stability of PSG findings in individuals are lacking. Do they represent ID traits or states of arousal? How stable are objective findings in individuals?
- Subtypes of ID lack sufficient support for clinical practice. Do we propose a spectrum of findings, or can we improve evidence on the relevance of subtypes?
- Objective measures correlate insufficiently with symptom severity and the diagnostic and therapeutic pathway. Do we need to establish finer-grained approaches?
- Can we establish PSG-derived biomarkers that better represent ID?
- Does PSG significantly improve feasibility or success rates of CBT-I?
- Can we reduce cost by defining a simpler technical set-up to improve availability?
- The current diagnostic framework has changed perception of ID from an isolated, rather psychological disorder to include a broader variety of patients with sleep continuity and daytime impairments. It is unclear whether this change diminishes the usefulness of PSG due to higher heterogeneity or increases the need to differentiate subtypes of this broader 'umbrella' category based on PSG.

7 | SUMMARY

Overall, the history of PSG in ID can be considered one of mostly unfulfilled hopes and promises. While there are several aspects of sleep medicine where PSG is clearly recommended and validated as an objective measure (e.g., for diagnosis of sleep disordered breathing), its validity to capture, characterise and diagnose ID remains insufficient. Still, due to the rising understanding of the importance of these underdiagnosed comorbidities, e.g., COMISA, PSG should be applied more often in patients with sleep continuity complaints. Several interesting concepts for a specific role of PSG in ID itself exist (e.g., identification of subtypes, individualised therapy), but need scientific clarification to warrant implementation in clinical practice.

AUTHOR CONTRIBUTIONS

Lukas Frase: Writing – original draft; conceptualization; writing – review and editing; visualization. **Christoph Nissen:** Writing – review and editing; conceptualization. **Kai Spiegelhalder:** Conceptualization; writing – review and editing. **Bernd Feige:** Conceptualization; visualization; writing – review and editing; writing – original draft.

CONFLICT OF INTEREST STATEMENT

Christoph Nissen has served on advisory boards of Idorsia and Janssen. All other authors declare no conflicts of interest.

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DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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