Using actigraphy versus polysomnography in the clinical assessment of chronic insomnia (retrospective analysis of 27 patients)

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\textbf{Summary}

\textbf{Aim} > The current study was conducted in order to investigate whether several different methods of characterizing sleep and insomnia symptoms produce different diagnoses.

\textbf{Method} > To this aim, we performed a retrospective study in order to compare the outcome of the assessment obtained using actigraphy with that obtained using polysomnography (PSG) in 27 outpatients complaining of chronic insomnia. Subjects were recruited from a database consisting of patients referred to the sleep centre of the Hôtel-Dieu Hospital (Paris) complaining of chronic insomnia. Patients were divided into different groups with regard to type of insomnia.

\textbf{Results} > As far as type of insomnia was concerned, the comparison between actigraphy and PSG showed quite a good contingency coefficient value ($\chi = 0.64$).

\textbf{Conclusion} > Although this was a preliminary and retrospective study, our results seemed to indicate that actigraphy and PSG were able to lead to a similar output particularly with regard to type of insomnia. Beyond PSG, actigraphy might have a clinical utility in assessing sleep disorders in adults complaining of chronic insomnia.
Insomnia is the most common sleep complaint across all stages of adulthood, and in most cases, it is chronic [1,2]. Some evidence highlights the daytime repercussions of insomnia and the consequences regarding social and cognitive functioning, suggesting that this disorder may reduce quality of life and hinder social and occupational functioning [3]. Insomnia can be classified in terms of presentation of complaints, duration, symptom severity and cause [1,4]. With regard to the type of insomnia, an insomnia sufferer may report difficulty in initiating sleep, difficulty in maintaining sleep and/or waking up too early. According to its duration, transient insomnia can be distinguished from chronic insomnia, the latter sleep disorder being categorized as having a minimum duration of at least 1 month and according to some classifications, of at least 6 months. When the insomnia reports at least two sleep complaints at least 3 times a week for at least 1 month, along with a complaint of impaired daytime functioning, he or she is likely to present a more severe insomnia. Finally, as to the cause, the International Classification of Sleep Disorders (ICSD-2) [5] distinguishes between insomnia as an independent disorder (primary insomnia) and insomnia arising as a symptom related to mental disorders, medical conditions or other sleep disorders which can also contribute to insomnia (secondary insomnia).

Assessment of insomnia complaints should begin with a history obtained from the patient. According to the current recommendations [6–9], the primary focus should be on the functional impact and severity, and chronicity of the complaints, with rapid identification of target symptoms. At the same time, a psychological and a medical assessment is required in order to evaluate the most common psychiatric and medical conditions associated with insomnia. Moreover, most sleep laboratories and clinics also use sleep-logs, polysomnography and actigraphy to aid diagnosis. A sleep-log (diary), completed for at least 7 consecutive days, provides information on night-time sleep habits and it may be helpful in establishing a general insomnia diagnosis and identifying circadian rhythm disorders as a cause of insomnia. Polysomnography (PSG) is considered the gold standard for an objective assessment of sleep, providing an accurate measure of wake and sleep time, as well as of sleep stages. However, it is an expensive approach and its ecological validity is sometimes questionable. PSG is indicated in cases of suspected sleep-related breathing disorders or suspected periodic limb movement disorders, which are often present among individuals complaining of insomnia, or in patients with treatment-resistant insomnia [6,7,9].

Finally, an actigraph is worn like a watch on the wrist of the non-dominant hand (for an example see figure 1) and it measures motor activity. Actigraphy, which infers wakefulness and sleep from the presence or absence of limb movement, provides objective and naturalistic measurements of sleep pattern in the home environment at a lower cost than PSG [10,11]. Consequently, actigraphy is particularly useful for evaluating sleep over extended periods of time (e.g. 7 days) in the patient’s home environment, measuring night-to-night variability in sleep-wake patterns (figure 2). As reported in the latest update of the American Academy of Sleep Medicine [12], actigraphy was included as a measure of sleep duration and sleep patterns in diagnostic criteria for several specific sleep disorders in the second edition of the ICSD-2 [5]. The accuracy and clinical usefulness of actigraphy in the assessment of insomnia, however, is still controversial [13,14]. Therefore, there are several methods for characterizing sleep and insomnia symptoms. General practitioners expressed interest in obtaining information about these tools [15]. The goal of the present study was to compare the evaluation obtained using actigraphy to that obtained using PSG in patients complaining of chronic insomnia.

**Methods**

**Subjects**

Subjects were recruited from a database consisting of patients referred to the sleep centre of the Hôtel-Dieu Hospital (Paris).
complaining of chronic insomnia. This database consisted of patients who completed a sleep evaluation protocol under the supervision of accredited sleep specialists. This protocol included a semi-structured sleep interview and clinical interview aimed at assessing the most commonly comorbid conditions for insomnia (i.e., for example, narcolepsy, sleep apnea, restless legs, periodic limb movement). To assess the presence of depression and/or anxiety, patients filled in the Beck Depression Inventory (BDI) [16] and the Spielberg State-Trait Anxiety Inventory (STAI) [17]. After this first examination, patients were included in a day hospital procedure. Patients underwent continuous ambulatory PSG for one night in their own home, while they were actigraphically recorded for at least 7 consecutive days [18,19]. Polysomnographic recordings were obtained using the Medatec ambulatory PSG System with Brainnet version 375.41 software (Belgium). Monitoring consisted of eight electroencephalography (EEG) channels, two electrooculography (EOG) channels and a chin electromyogram (EMG). Sleep stages were visually scored using 30-second epochs according to Rechtschaffen and Kales’ standard scoring criteria [20]. In order to diagnose sleep apnea, supplementary channels, oxygen saturation level, heart rate, inductive plethysmography belts, nasal-pressure canula, thermal flow sensor and snore sensor were also recorded. For the diagnosis of restless leg syndrome, two-leg EMG were also used. Concomitantly, estimates of sleep parameters were obtained by means of wrist-mounted actigraph (Actiwatch; Cambridge Neurotechnology, Cambridge, UK), logged at 1-minute intervals and analysed (Actiwatch Activity & Sleep Analysis 5 version 5.32 software; Cambridge Neurotechnology) at autosensitivity [21]. Subjects were asked to press an event-marker button on the actigraph when they were ready to go to sleep and

**Figure 1**
An actigraph, a device generally placed on the wrist, which contains an accelerometer producing electrical impulses as a response to movement. Collected data are downloaded to a computer for evaluating subject’s activity/inactivity that, in turn, can be further analyzed to estimate wake/sleep.

**Figure 2**
Actograms, graphical tools commonly used in circadian research to plot 24-hour activity pattern.

2A normal sleeper actogram, 2B insomniac actogram.
immediately on awakening, as well as keeping a sleep diary. Using both event-marker points and information present in the diary, automatic scoring was checked by an experienced scorer to set the time spent in bed. If subjects provided only one source of information for a night (e.g., forgot to push the event-marker button), the scorer referred only to source of information provided. If both kinds of information were lacking, the night was not counted.

For this study, we selected from the database only patients with a diagnosis of primary insomnia according to the criteria of the ICSD-2 [5], who completed their sleep evaluation protocol from September 2009 to September 2010. Data collection and database were performed with informed consent.

Data analysis

For each selected patient, polysomnographic and actigraphic sleep parameters were reported in two anonymous files. As for sleep measures, the following parameters were considered: sleep onset latency (SOL), total sleep time (TST), wake after sleep onset (WASO), terminal wakefulness (TWAK) and sleep efficiency (SE). SOL is the interval (in minutes) from “lights off” to the beginning of sleep. TST is the sum (in minutes) of all sleep epochs between sleep onset and get up time. WASO is the sum (in minutes) of all awake epochs between sleep onset and get up time. TWAK is the amount of time awake between the final awakening and the time of getting out of bed. SE is the ratio of the total sleep time to time in bed multiplied by 100. As for PSG, in addition to the previous sleep measures, the sleep structure (quantified by computing the duration of each sleep phase as a percentage of total sleep time) and REM latency (time from sleep onset to the first appearance of REM sleep) are also reported.

Polysomnographic and actigraphic evaluation was based on the qualitative criteria of the ICSD-2 [5], as well as according to quantitative criteria which were a synthesis of those proposed in the literature [22,23] combined with clinical experience. Patients were classified as insomniacs if they reported at least one complaint of insomnia, with associated daytime impairment, at least three times a week for at least 6 months, with the sleep pattern being assessed by actigraphy over 7 nights or by PSG over 1 night with a SOL longer than 30 minutes (disorder of initiating sleep), or with frequent or extended nocturnal awakenings totalling more than 30 minutes of WASO (disorder of maintaining sleep), or a TST shorter than 360 minutes and a TWAK longer than 30 minutes (disorder of short duration sleep with early morning awakening), or a combination of the previous quantitative criteria (mixed disorder).

In order to describe the distribution of insomnia using both actigraphy and PSG and to address whether there was a relationship between the two methods, patients were divided into different groups with regard to type of insomnia.

The sample was divided into five main categories:

- disorder of initiating sleep;
- disorder of maintaining sleep;
- disorder of short duration sleep with early morning awakening;
- mixed disorder (i.e. patients reported at least two or more disorders);
- subjects who reported the occurrence of insomnia problems without satisfying the quantitative criteria.

The degree of association between actigraphy and PSG evaluations was assessed by the contingency coefficient C. The effect size is also calculated to study the effect of the sample size on the statistical significance according to Cohen’s criterions. The w index was used (small effect size: w = 0.10; medium effect size: w = 0.30; large effect size: w = 0.50) [24].

Results

Forty consecutive dossiers were selected in a first phase. Of these, we included in our study only patients who contributed at least one valid night of PSG and seven valid nights of actigraphy. The final study sample consisted of 27 patients (six males, 21 females), aged 41.85 ± 12.32, reported to have been affected by insomnia for 10.58 years (SD = 7.17). The average score for the BDI was 6.25 (SD 4.25). The average score for the STAI, trait scale, was 47.88 (SD 9.53). As for medication, 51.9% of the sample took hypnotics, 7.4% took antihistaminics, 3.7% took antidepressants, 3.7% took herbal and natural substances, 7.4% took both hypnotics and antidepressants, and 25.9% were drug free. Finally, regarding substance use, participants did not abuse alcohol, caffeine or nicotine.

We performed five independent sample t tests to compare actigraphic and PSG mean sleep measures. The mean sleep measure values and standard deviations for actigraphy (7 nights) and PSG (1 night) are shown in Table I. In our sample, the sleep variables producing significant differences among the means were TST (t(26) = 2.76, P < 0.05) and TWAK (t(26) = 5.40, P < 0.0001).

The distribution of type of insomnia, reported (i.e. subjective complaint) and measured through actigraphy and PSG, is shown in Table II.

According to actigraphy, the 70.4% of patients who reported insomnia met the criteria for insomnia using actigraphy, whereas the 77.8% of patients who reported insomnia met the criteria for insomnia using PSG. That is, the 29.6% of the sample reported the occurrence of insomnia problems without satisfying criteria for insomnia (i.e. they misperceived their sleep) using actigraphy, the 22.2% using PSG. Overall, actigraphy and PSG were in agreement in 17 cases out of 27 (63.0%): according to the two tools, the 55.6% of the sample presented insomnia and the 7.4% of the sample misperceived his own sleep.
With regard to the type of insomnia, the degree of association between actigraphy and PSG was significant \((C = 0.64; \chi^2 = 18.83; P < 0.05; w = 0.83)\). Thus, 48.2% of the sample was classified as belonging to the same insomnia type category by both tools.

Finally, with regard to insomnia type, the association between reported complaint and the evaluation using each diagnostic tool was not significant (actigraphy: \(C = 0.41; \chi^2 = 5.41; P = 0.49; w = 0.45; \) PSG: \(C = 0.45; \chi^2 = 6.85; P = 0.34; w = 0.50\)).

**Discussion**

There were two significant differences between actigraphy and PSG regarding total sleep time and, in particular, terminal wakefulness. We think that these differences, particularly as far as TWAK is concerned, can be attributed to the two different recording procedures: 1 night (PSG) versus 7 nights (actigraphy) as a recording time and a different recording setting so that, for example, PSG could have induced the subject to get up as soon as he/she awoke.

On the whole, our results indicated that actigraphy and PSG similarly detected the presence of insomnia, that is, in our sample, in the majority of cases, both tools discriminated similarly between subjects who met the criteria for insomnia. Moreover, if we considered insomnia type, the contingency coefficient was quite good, with a large size effect, suggesting that actigraphy and PSG were able to lead to a similar output.

Regarding the agreement between patients’ subjective complaints and objective evaluations, this study is in line with the literature on disagreement between sleep measures [25,26]. For example, taking into account total sleep time, one of the most important parameters used to characterize a person’s sleep pattern, Van den Berg et al. [25] found that the estimated TST in the sleep diaries deviated more than 1 h from actigraphically measured TST and Vallières and Morin [26] showed that compared to PSG, sleep diaries underestimated TST. A number of factors may influence the perception of sleep [27]; among these factors, we can assume, is the decision of patients to see a sleep specialist only after several years of disease, thus often presenting a severe and poly-symptomatic disorder rather than a single disorder. This phenomenon was recently reported in the EQUINOX survey [28], an international study addressing insomnia in general practice.

Considering this background information, together with the literature [6,25], we agree with the recommendation to use, in adults complaining of chronic insomnia, a multiple sleep assessment method in order to understand the different components of insomnia. To be more precise, we agree with the suggestion to use PSG when a specific sleep disorder, such as a periodic limb movement disorder, could be responsible for the insomnia complaint brought forward by the patient [6,8,9], but, considering our results, we also highlight the clinical utility of actigraphy for evaluating adults complaining of chronic insomnia. Indeed, actigraphy makes it possible to obtain a measure of sleep patterns spanning 7 or more days, in an ecological setting.
and at a lower cost than that incurred when using PSG. From this point of view, actigraphy is an inexpensive approach to gathering objective data on the rest-activity cycle and may be an interesting solution in the management of insomnia where the objective is to provide an early diagnosis. Actigraphy could also be useful within an early screening context. The use of actigraphy requires additional research [29]. On one hand, actigraphy partially shares with PSG the lack of cut-off criteria [22,23]. Future research is needed to determine quantitative criteria to adopt in clinical practice [30]. On the other hand, in accordance with the latest American Academy of Sleep Medicine update [12], further work is needed to establish standards of actigraphy technology. To date, the generalization of results is greatly-restricted because of the availability of diverse devices which use different technology for detecting movement and of different types of software analysis.

Our results should be considered with caution, given the methodological limitations concerning the sample dimension. However, the selected sample is homogenous, including only patients with primary insomnia; each of them had one valid night of PSG and seven valid nights of actigraphy. Moreover, the \( w \) index supports our results. Further studies should clarify the contribution of sleep-logs, actigraphy and PSG to the diagnosis of sleep disorders, in order to provide recommendations on insomnia assessment within different settings, from primary care to sleep disorder centres.

Disclosure of interest: the authors declare that they have no conflicts of interest concerning this article.

References


