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Original Article

The role of actigraphy in the assessment of primary insomnia: a retrospective study

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ABSTRACT

Objective: The aim of our study was to evaluate quantitative actigraphic criteria obtained using the Actiwatch device (AW64; Cambridge Neurotechnology Ltd., Cambridge, UK) to differentiate participants with insomnia from normal sleepers.

Methods: In our retrospective study, we recovered 493 actigraphic records from two sleep measure databases of patients with insomnia ($n = 151$) and one of normal sleepers ($n = 342$). We considered the following actigraphic sleep parameters: time in bed (TIB), sleep-onset latency (SOL), total sleep time (TST), wake after sleep onset (WASO), sleep efficiency (SE), number of awakenings (NWAK), terminal wakefulness (TWAK), fragmentation index (FI), and mean motor activity (MA). We also considered two actigraphic circadian indexes: interdaily stability and intradaily variability. Using the Youden index, we calculated the quantitative actigraphic criteria that performed best for each actigraphic sleep parameter. Finally, we created receiver operating characteristic curves to test the accuracy of each criterion identified.

Results: All sleep parameters except TST and TWAK differentiated the two groups of participants, allowing calculation of quantitative actigraphic criteria. There were no differences in the circadian indices.

Conclusions: The quantitative actigraphic criteria obtained in our study were not the same as those obtained previously with a different device, suggesting the need to adopt shared technical solutions for actigraphy.

1. Introduction

Epidemiologic data indicate that insomnia is the most common sleep concern in the industrial world [1]. The *International Classification of Sleep Disorders*, Second Edition (ICSD-2) [2], identifies insomnia as one of eight major categories of sleep disorders and lists 12 specific insomnia disorders within this group. Insomnia can be defined as a subjective report of difficulty with sleep initiation, duration, consolidation, or quality occurring despite adequate opportunity for sleep resulting in daytime impairment. Routine clinical evaluation of a patient with insomnia essentially consists of carefully collecting the patient's sleep history, performing a clinical interview and standard questionnaires, and conducting a physical and mental status examination. Objective sleep assessment is only recommended in specific cases to provide supporting information [3,4].

One of the 12 specific types of insomnia is paradoxical insomnia, previously termed *sleep-state misperception*, i.e., a condition in which there is a complaint of insomnia without objective evidence of a sleep disorder. The computation of a misperception index has recently been proposed (objective total sleep time [TST] – subjective TST/objective TST), in which positive values correspond to underestimation of sleep time and negative values to overestimation [5]. Harvey and Tang [6] did not exclude the possibility that such an index could be added to the standard research assessment of insomnia, making objective sleep assessment a necessary part of the clinical evaluation of patients with insomnia [7,8].

However, objective sleep evaluation still creates pragmatic problems. The accepted gold standard for sleep assessment is polysomnography (PSG). This technique requires that participants either come to a sleep laboratory or be connected to portable PSG equipment at home, creating a considerable burden to participants and increasing study costs. Moreover, because of the high variability of insomniac sleep and problems related to the first-night effect, PSG is not indicated for routine evaluation of chronic insomnia [9]. A possible alternative to PSG could be actigraphy

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[10–12]. Actigraphy has several limitations and strengths compared to PSG. On the one hand, actigraphy measures motor activity, and hence only indirectly sleep; sleep-stage identification is not possible. On the other hand, actigraphy is less costly and less intrusive than PSG. Patients can be studied in their own home environment for multiple nights. It provides additional information about daily and circadian patterns of motor activity, and it is relatively easy to use in ambulatory settings [13].

One of the unresolved limits of actigraphy is the lack of quantitative criteria for the assessment of sleep quality. Vallières and Morin [14] showed that actigraphy is a reliable method for monitoring treatment response among patients with insomnia, i.e., for comparing pre- and posttreatment sleep quality. However, without standard quantitative criteria, it is difficult to use actigraphy for the diagnosis of primary insomnia. The best way to develop quantitative actigraphic criteria (QAC) would be to collect actigraphic data from a large sample of normal sleepers and to compare it with actigraphic data from patients with insomnia, enabling actigraphic cutoff values to be identified for assessment of sleep quality. Using the Basic Mini-Motion logger (Ambulatory Monitoring, Inc., Ardsley, NY), a recent study suggested preliminary QAC for the assessment of sleep quality in patients with primary insomnia [15]. The cutoff values were 12 min for sleep-onset latency (SOL), 16 movements for motor activity (mean number of movements within 1 min), 25 min for wake after sleep onset (WASO), and 92% for sleep efficiency (SE). However, these results were derived from a single limited sample using only one type of actigraph, and the study needs to be repeated in a larger sample and using different actigraph models.

Therefore, the aim of our study was to assess which QAC may be of use to differentiate participants with insomnia from participants with normal sleep using a different actigraph device (the Actiwatch – AW64; Cambridge Neurotechnology Ltd., Cambridge, UK) in a larger group of participants.

2. Methods

2.1. Population

We performed a retrospective study using actigraphic records from three anonymous databases. Informed consent was obtained for each database before original data collection. Actigraphic recordings of patients with insomnia came from the Centre du Sommeil et de la Vigilance, Hôtel-Dieu de Paris (database A) and the Service for Diagnosis and Treatment of Insomnia of the Department of Psychology, University of Bologna (database B). At the time of assessment, all participants underwent a 3-week sleep evaluation protocol; the actigraphy was performed during the second week of this protocol.

2.1.1. Inclusion criteria

We only included patients with a diagnosis of primary insomnia according to the qualitative criteria of the ICSD-2 and the research diagnostic criteria for primary insomnia [19] based on subjective complaints and clinical interviews according to the published recommendations for a standard research assessment of insomnia [3].

Patients must have complained of nocturnal sleep difficulties for at least three nights a week and for at least 6 months, with associated impact on daytime activities. The diagnosis of primary insomnia was confirmed in the two clinical centers under the supervision of accredited sleep specialists using semistructured interviews.

2.1.2. Exclusion criteria

Based on these interviews, participants with other sleep diagnoses, such as narcolepsy, sleep apnea, restless legs syndrome, or periodic limb movement disorder (PLMD), were excluded. Patients with psychiatric disorders or those who were using psychoactive medications or other drugs that can affect sleep (e.g., corticosteroids, β blockers) also were excluded. During the clinical assessments, patients were systematically assessed for significant symptoms of depression or anxiety using the Beck Depression Inventory [20] and the State-Trait Anxiety Inventory [21]. Patients with a Beck Depression Inventory score of 20 or higher or a State-Trait Anxiety Inventory score of 40 or higher were not considered as having primary insomnia.

Thus the final sample consisted of 151 patients with primary insomnia (55 men and 96 women), aged 42.67 ± 14.81 years (range, 15–76 years). Database C (control group) was compiled at the Laboratory of Applied Chronopsychology of the Department of Psychology, University of Bologna, Italy, using a series of previous studies [17,22–24] involving healthy participants. We retrospectively included 342 participants (142 men and 200 women) aged 31.81 ± 17.22 years (range, 15–82 years) from this database. None of the participants worked flexible time schedules or night shifts and none had complained of sleep disturbance or daytime symptoms due to unsatisfactory sleep. The exclusion criteria used in our previous studies [17,22–24] included sleep disorders, mental disorders, serious or acute illness, use of psychoactive medication, and disabilities interfering with or restricting mobility [3]. For inclusion in these previous studies [17,22–24], participants had to complete the 12-item General Health Questionnaire [25], the Sleep Disorders Questionnaire [26], and the Profile of Mood States [27]; participants who did not report any sleep disorder in the Sleep Disorders Questionnaire were included if they had a General Health Questionnaire score of four or less and a Profile of Mood States score of 250 or less.

2.2. Actigraphy

2.2.1. Hardware

The Actiwatch (AW64, Cambridge Neurotechnology Ltd., Cambridge, UK) device was used. The device hardware consists of a piezoelectric accelerometer with a sensitivity of $\geqslant$0.05 g. The sampling frequency is 32 Hz. Filters are set to 3–11 Hz by default. The Actiwatch weighs 16 g and has a nonvolatile memory of 64 Kb. Actigraphs were initialized by Actiwatch Activity and Sleep Analysis, version 5.32 (Cambridge Neurotechnology Ltd., Cambridge, UK) to collect data in 1-min epochs in accordance with the 2002 practice parameters for the use of actigraphy [10].

2.2.2. Software

Actigraph data files were analyzed by Actiwatch Activity and Sleep Analysis, version 5.32 (Cambridge Neurotechnology Ltd., Cambridge, UK). This software identified each epoch as sleep or wake using the mathematical model developed and validated by Oakley [16]. Sleep was scored when the total activity count (A) was equal to or less than the activity threshold setting according to the following formula: A = an2(1/25) + an1(1/5) + a + a1(1/5) + a2(1/25), in which an2 and an1 were the activity counts from the prior 2 min and a1 and a2 were the subsequent 2 min.

2.2.3. Sensitivity threshold

The clinician could set the wake sensitivity threshold as high (20 counts per epoch), medium (40 counts per epoch), low (80 counts per epoch), or auto (mean score in active period*0.888/epoch length) before sleep scoring. No specific recommendations were provided by the manufacturer on how to use these thresholds. Thus to explore which threshold best discriminates patients with primary insomnia from normal sleepers, we considered all four AW64 wake sensitivity settings.