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Use of Actigraphy in Neurological Patient Populations

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Abstract

An actigraph is a portable device that measures movement, usually of the non-dominant wrist, to estimate rest-activity patterns and sleep-wake cycles. The use of actigraphy has grown over the past decade. Actigraphy has gained favor in the sleep community for the evaluation of insomnia and circadian rhythm disorders, and the device has become an important research tool. As sleep disorders are common in neurological patient populations, the use of actigraphy has increased in the clinical evaluation of neurological patients, particularly in patients with dementia, head trauma and autistic spectrum disorders. At the same time, actigraphy has grown as a clinical research instrument in neurological patient populations.

Introduction

An actigraph is a portable device that senses physical motion. It contains an accelerometer that generates an internal signal each time the device is moved. Signals are processed several times a second. The device contains enough memory to record up to several weeks of data. When worn on a patient's non-dominant wrist, the actigraph estimates sleep-wake patterns based on rest-activity rhythms (Figure 1). Use of actigraphy in the sleep literature is focused on diagnosis of circadian rhythm disorders and insomnia as well as evaluation of treatment response in normal, healthy populations.[1] The literature also recognizes the utility of the actigraph in patients who cannot cooperate with polysomnography (PSG) and/or cannot keep accurate sleep logs, such as demented nursing home patients or special pediatric populations. Based on recent guidelines, actigraphy is also indicated to estimate total sleep time in patients with obstructive sleep apnea when PSG is not available.[1] Actigraphy is an important research tool and is gaining favor for more widespread clinical use.

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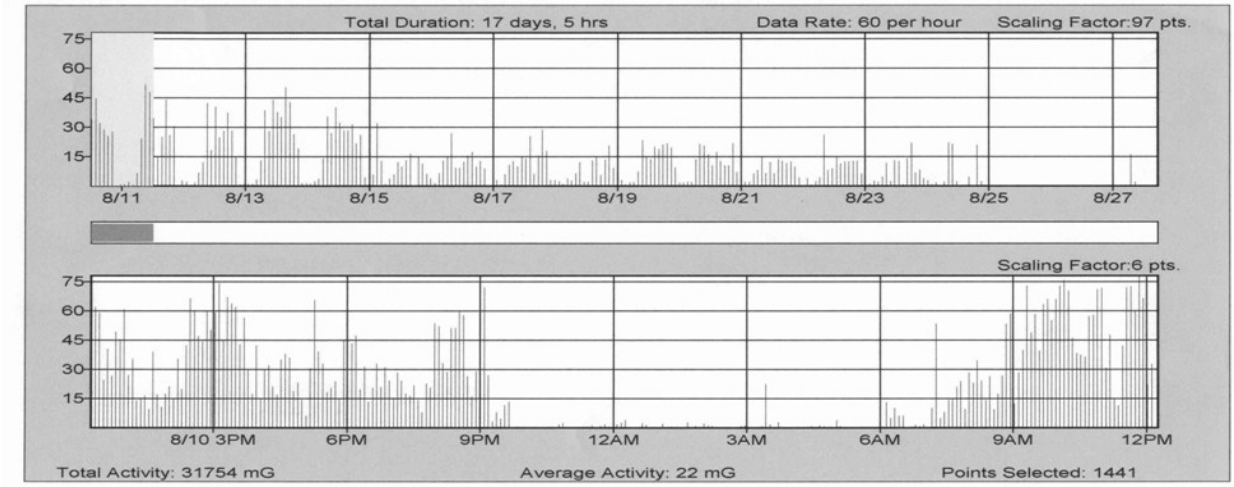

Figure 1: Actigraphy data collected from a patient in our institution with a history of complex partial seizures. The top panel displays compressed data over several days. The bottom panel demonstrates the rest-activity pattern over a single 24 hour period.

Actigraphy has been used in the evaluation of sleep disorders in neurological patient populations and has several key advantages. It permits long term monitoring in the patients' home environment. It is an inexpensive tool that causes little inconvenience to the patient. Additionally, an actigraph watch can be used in patients who are unable to cooperate with PSG. The purpose of this article is to review the use of actigraphy in the evaluation of disorders in specific neurological patient populations both in the clinical and the research arena.

Neurological Conditions Studied by Actigraphy

Dementia

Sleep disorders are common in patients with dementia and are described in up to 44% of patients with Alzheimer's Disease (AD).[2] Sleep disturbance has the potential to adversely affect quality of life for patients and caregivers and, possibly, worsen cognition and behavior. Another repercussion is caregiver exhaustion, increasing the likelihood of institutionalization of demented patients.[3]

Early morning awakening, frequent nighttime awakening, and hypersomnia with daytime napping are among the most common sleep disturbances in this patient population.[2] Because shifts in circadian rhythms are common among demented patients, actigraphy can be useful in diagnosis of sleep disturbance via long term monitoring of sleep-wake patterns. Actigraphy is often a favorable alterative to PSG and sleep logs in this population. PSG permits only short term monitoring and is often impractical in significantly demented patients. Similarly, demented patients are frequently unable to provide accurate information about their sleep in the form of a sleep log. Even external observers, such as nurses, have proven less accurate in detecting nighttime awakenings than actigraphy.[4]

Several studies have examined the use of actigraphy in characterization of circadian patterns among demented patients.[4-6] Harper et al.[7] discovered potential inherent differences in circadian rhythm disturbances between patients with AD and frontotemporal dementia using actigraphic and temperature

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measurements. Similarly, actigraphy has been utilized to study potential treatments for demented patients with sleep disturbances. Though with conflicting results, both Ancoli-Israel et al.[8] and Dowling et al.[9] used actigraphy to study the use of light therapy in institutionalized patients with AD and circadian rhythm disorders. Singer et al.[10] utilized actigraphically-derived sleep measures to examine the use of melatonin to treat sleep disturbances in patients with AD without attaining significant results.

Head Trauma

Sleep disorders are common following traumatic brain injury (TBI), with a frequency ranging from 36% to 70%.[11] Insomnia, hypersomnia and disturbances of the sleep-wake cycle are frequent complaints following head trauma.[11, 12] Sleep disorders can impair quality of life and affect cognitive functioning in trauma patients. Castriotta et al.[13] found that trauma patients with subjective excessive daytime sleepiness (EDS) and objective EDS based on Multiple Sleep Latency Test (MSLT) had decreased performance on psychomotor vigilance testing compared to trauma patients without EDS.

Actigraphy has been studied extensively for use in evaluation of insomnia and circadian rhythm disorders, potentially making it an important tool in the evaluation of sleep disturbance in TBI. In one study, 50.2 % of TBI patients reported insomnia symptoms, while 29.4% fulfilled diagnostic criteria for an insomnia syndrome.[14] Ayalon et al.[15] found that 36% of TBI patients who complained of insomnia had circadian rhythm disorders, either delayed phase sleep syndrome or irregular sleep-wake pattern. However, Verma et al.[16] retrospectively noted that many TBI patients who complained of hypersomnolence were diagnosed with common sleep disorders like obstructive sleep apnea. Therefore, actigraphy does not obviate the need for PSG in TBI patients.

Several studies have used actigraphy for the characterization of sleep disorders. Ayalon et al.[15] used actigraphy to characterize circadian disorders in TBI patients, who also underwent PSG. Kaufman et al.[17] performed both actigraphy and PSG in 19 adolescents with a history of mild TBI. PSG and actigraphy revealed the same findings: poor sleep efficiency, more wake time, and more frequent awakenings lasting 3-5 minutes in TBI patients.

Autistic Spectrum Disorders

Sleep disorders are common in children and adults with autistic spectrum disorders.[18] Difficulties with sleep may contribute to behavioral, psychiatric and learning problems in this patient population.[19, 20] The most common sleep problem described in patients with autistic spectrum disorders is insomnia, which often presents as trouble getting to sleep, night waking, short duration sleep, early morning waking, and daytime sleepiness.[21]

Actigraphy has gained favor as an objective measure of sleep-wake patterns, providing important supplemental information to parent history/diaries. Wiggs and Stores[21] characterized sleep disorders in children with autistic spectrum disorders using both actigraphy and sleep logs provided by parents. Underlying sleep disorders were frequent and characterized as behavioral sleep problems, circadian sleep–wake problems and anxiety-associated sleep problems. Allik et al.[18] compared children with Asperger Syndrome to age-matched controls using actigraphy and sleep logs. Children with Asperger Syndrome were found to have longer sleep onset latencies and lower sleep efficiency, which supported parental reports of difficulty falling asleep. Actigraphy can provide long term monitoring to diagnose insomnia. However, PSG remains important to rule out sleep apnea in

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certain cases.[22]

Actigraphy is also being used to monitor response to treatment of sleep disorders in patients with autistic spectrum disorders. Paavonen et al.[20] monitored the effectiveness of melatonin in improving sleep and behavior in an open uncontrolled clinical trial of patients with Asperger Syndrome using questionnaires and actigraphy. Actigraphy displayed improvement in sleep latency and subjective measures of behavior in these patients.

Multiple Sclerosis

Actigraphy has been used in multiple sclerosis (MS) as a research tool. A few studies have utilized actigraphy in MS patients with complaints of fatigue. Taphoorn et al.[23] examined sleep-wake patterns in MS patients with actigraphy and compared them to normal controls. The study did not find any evidence of circadian rhythm disorders in MS patients or any correlation between fatigue and objective evidence of sleep disturbance. Attarian et al.[24] used actigraphy to examine rest activity patterns in MS patients who complained of fatigue and compared this data to MS patients who did not complain of fatigue and to healthy age-matched controls. This study did find a correlation between sleep disturbance as detected by actigraphy and subjective accounts of fatigue.

Headache

Actigraph watches have been used experimentally in headache. Bruni et al.[25] examined actigraphic data and self-report diaries in children with migraine compared with age-matched controls to evaluate sleep patterns between attacks of migraine and to look for changes in sleep-wake patterns before, during, and after a migraine headache. There was no significant difference between interictal sleep patterns in patients with migraine compared to controls. However, there was a significant decrease in nocturnal motor activity measured by actigraphy the night prior to a migraine attack. Kikuchi et al.[26] used actigraphy to examine activity patterns during and subsequent to episodes of tension headache, noting a significant decrease of activity in the setting of tension headache.

Stroke

A few studies have also looked at actigraphy data in stroke patients. Stergiou et al.[27] studied variation in blood pressure, heart rate, activity level and onset of stroke throughout the day. Morning and evening peaks in blood pressure, heart rate and activity level correlated with peaks in onset of stroke, suggesting that circadian patterns are related to stroke. Bassetti and Valko[28] used actigraphy to detect post-stroke hypersomnia, which may be associated with more severe stroke and poorer short term outcomes.

Diagnosis of Sleep Disorders: Actigraphy vs. Polysomnography and Sleep Logs

Actigraphy has several key advantages and disadvantages when compared with PSG and sleep logs. Compared to PSG, actigraphy permits longer term monitoring in the patient's home environment. This avoids the first-night effect, which causes disruption of sleep structure primarily during the first night of recording in a laboratory setting. Additionally, circadian patterns can be better estimated with recordings over days/weeks, which is not feasible in PSG. Actigraphy can be used in patients in whom PSG is not possible. Actigraphy permits objective measurement of rest-activity rhythms, unlike sleep logs which rely on patient cooperation. Thus, actigraphy is especially useful in patients who cannot reliably document their sleep patterns.

There are several factors that restrict the use of actigraphy alone for diagnosis of sleep

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disorders. Actigraphy cannot estimate stages of sleep, which limits its utility in many disorders including narcolepsy. Outside of circadian rhythm disorders or insomnia, it must be used in conjunction with PSG to diagnose conditions like sleep disordered breathing (SDB) or periodic limb movements of sleep (PLMS). Even in conditions like insomnia, it is often important to rule out underlying disorders like SDB or PLMS. Finally, more data need to be collected to compare actigraphy to PSG, which remains the reference standard.

Conclusion and Future Directions

Actigraphy is gaining favor for use in sleep research and clinical care of insomnia and circadian rhythm disorders. Actigraphy is often most useful when combined with other techniques like PSG, sleep logs or MSLT, as dictated by clinical symptoms and patient cooperation. There are many neurological patients who suffer from insomnia and circadian rhythm disorders. In particular, patients with dementia, head trauma and circadian rhythm disorders can benefit from the use of actigraphy for diagnosis of sleep disturbance and measurement of response to treatment. Actigraphy has also emerged as a research tool for evaluation of sleep-wake patterns in MS, headache and stroke.

While additional research is still needed to establish standards for use and scoring of actigraphy and to compare it to reference techniques like PSG[1], actigraphy has advantages that can potentially benefit neurological populations with sleep disorders. One such population in which actigraphy has not been extensively studied is the epilepsy population. The mutually influential relationship between sleep and epilepsy has long been recognized. The influence of sleep deprivation on epileptic seizures continues to be debated. Actigraphy has not yet been used in epilepsy patients to study rest-activity patterns interictally, as well as to look for changes in patterns occurring prior to seizure onset. Perhaps actigraphy can provide a possible association between rest-activity patterns and seizure frequency.

Beyond diagnosing and treating sleep disorders, one can conceivably study the therapeutic utility of improving sleep in patients with epilepsy, dementia, stroke, headache and MS. For example, actigraphy has been used to determine the relationship between sleep patterns and fatigue in MS patients. It will be interesting to see if improving sleep actually affects patient response to immunotherapy, as sleep is known to influence the immune system. Similarly, it would be helpful to quantify the effect of improving sleep patterns on patients with medically refractory epilepsy.

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