Sleep Medicine Reviews 15 (2011) 259–267

Contents lists available at ScienceDirect

Sleep Medicine Reviews

journal homepage: www.elsevier.com/locate/smrv

CLINICAL REVIEW

The role and validity of actigraphy in sleep medicine: An update

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ARTICLE INFO

Article history:
Received 23 July 2010
Received in revised form
25 October 2010
Accepted 27 October 2010
Available online 14 January 2011

Keywords:
Actigraphy
Actimetry
Activity
Sleep
Movements

SUMMARY

Activity-based sleep-wake monitoring or actigraphy has gained a central role as a sleep assessment tool in sleep medicine. It is used for sleep assessment in clinical sleep research, and as a diagnostic tool in sleep medicine. This update indicates that according to most studies, actigraphy has reasonable validity and reliability in normal individuals with relatively good sleep patterns. The validity of actigraphy in special populations or with individuals with poor sleep or with other sleep-related disorders is more questionable. The most problematic validity issue is the low specificity of actigraphy in detecting wakefulness within sleep periods reported with certain devices or samples. Overall, the recent literature adds to previous reports in demonstrating that actigraphy is sensitive in detecting unique sleep patterns associated with specific sleep disorders as well as with other medical or neurobehavioral disorders. Furthermore, actigraphy is sensitive in detecting sleep changes associated with drug treatments and non-pharmacologic interventions. Recent developments include the development of devices specially tailored to detect periodic limb movement in sleep and the introduction of new devices and algorithms. Because of the limitations of actigraphy, it is recommended to use complementary assessment methods (objective and subjective) whenever possible.

Introduction

Over the last two decades actigraphy has become a major assessment tool in sleep research and sleep medicine. The rate of relative growth in number of scientific publications that include actigraphy (see Fig. 1) exceeds the rate of growth in publications that include polysomnography (PSG) (from an actigraphy-PSG ratio of about 1:10 in 1991 to a ratio of about 1:4 in 2009). This increase reflects the growing appeal of actigraphy to clinicians and researchers in sleep medicine. Earlier reviews and guidelines introduced by the American Sleep Disorders Association (ASDA) have established the use of actigraphy as a reliable and valid sleep assessment method in specific domains of sleep research and sleep medicine.[1–6] The current review is an update based on the literature published after the previous review published in 2002 in Sleep Medicine Reviews.[6] It is based on a literature search that included Pubmed, Social and Science Citation Index databases and covers only articles published in peer-reviewed journals (excluding meeting abstracts or proceedings). Because of the large number of papers published each year, this review covers only papers that address methodological issues related to the use of actigraphy in sleep medicine and those that are directly related to clinical applications in sleep medicine. Thus, dozens of papers, addressing the use of actigraphy in assessing sleep in specific conditions or populations were not included.

Actigraphy is based on small wrist-watch like devices that monitor movements for extended periods of time. The raw activity scores (e.g., in 1-min epochs) are translated to sleep-wake scores based on computerized scoring algorithms. There are different commercial devices in the market and each device has its own measurement characteristics and therefore requires appropriate sleep-wake scoring algorithms and validation studies. To avoid commercial pitfalls, this review will not address specific devices or comparisons, but the readers are strongly advised to consider the presented issues and their relevance to the specific device they are using or planning to use.

Reliability and validity issues

The strengths and limitations of actigraphy in sleep assessment have been repeatedly outlined.[1–6] In this section, additional information is provided with regard to the main established topics and some new ones.

Validation of scoring algorithms

Previous work has established the reliability and validity of actigraphy in sleep-wake detection, particularly in normal populations

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doi:10.1016/j.smrv.2010.10.001

Abbreviations

AHI	Apnea-hypopnea index
CBT	Cognitive-behavioral therapy
MPH	Methylphenidate
PLMD	Periodic limb movements disorder
PLMS	Periodic limb movements in sleep
PSG	Polysomnography
SDB	Sleep-disordered breathing
SE	Sleep efficiency
SOL	Sleep onset latency
TIB	Time in bed
TST	Total sleep time
WASO	Wake after sleep onset

of infants, children and adults.[1–3] However, recent publications have raised new concerns about the validity of sleep-wake scoring algorithms in specific populations or specific devices.[7–11] For instance, Sitnick et al.[8] compared minute-by-minute sleep-wake scorings based on actigraphy and videosomnography in young children. They reported 94% overall agreement, 97% sensitivity (percent of PSG identified sleep minutes scored as sleep minutes by actigraphy), and 24% (very low) specificity (percent of PSG identified wake minutes scored as wake minutes by actigraph). Similarly, Insana et al.[7] compared sleep-wake scorings based on actigraphy and PSG in infants and found low specificity because of poor wake identification. De Souza et al.[11] reported relatively low specificity (34% and 44%) in their comparison of PSG and two actigraphic scoring algorithms in healthy volunteers. Paquet et al.[10] compared two actigraphic sleep scoring algorithms in a study of 15 healthy participants studied for 3 nights with concomitant PSG and actigraphy. They found that increasing wakefulness during the sleep period compromises the minute-by-minute actigraphy-PSG correspondence because of the relatively low specificity of the sleep-wake scoring algorithms. The authors concluded that "the very low ability of actigraphy to detect wakefulness casts doubt on its validity to measure sleep quality in clinical populations with fragmented sleep".

These examples demonstrate a crucial issue. Although actigraphy provides high sensitivity, the detection of wakefulness during sleep episodes is relatively poor with: a) some devices; b) some scoring algorithms; or c) some specific populations. This is a major issue which relates to the combination of high sensitivity and low specificity in sleep-wake detection. To clarify this issue, we can assume that we have a 10-hour sleep period with a 1-hour of

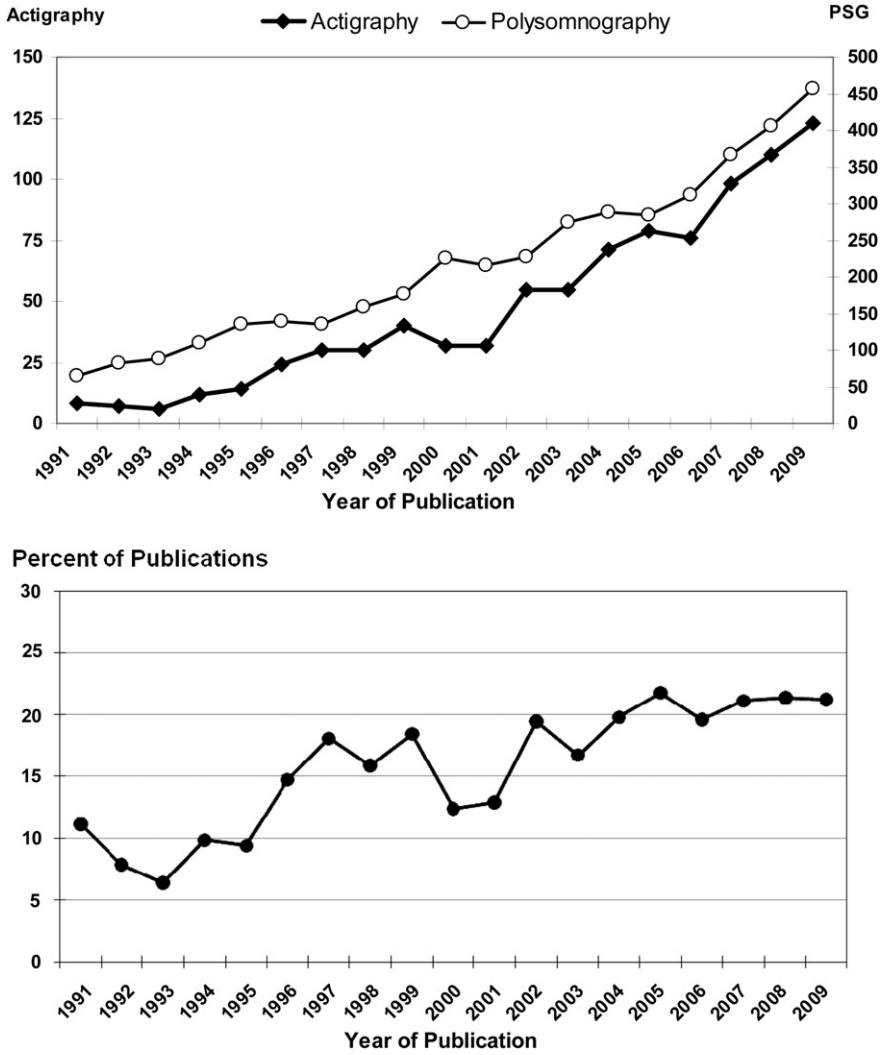

Fig. 1. The number of scientific publications that include actigraphy or actimetry and sleep in comparison to those which include polysomnography in their title or abstract (upper panel). These data are based on the ISI database and do not include meeting abstracts and proceedings. Note the different Y scales for actigraphy (on the left) and PSG (on the right). The lower panel presents the percentage of actigraphy publications from all polysomnography and actigraphy publications in each year.