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CLINICAL REVIEW

Leg actigraphy to quantify periodic limb movements of sleep: A systematic review and meta-analysis

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SUMMARY

Periodic limb movements of sleep (PLMS) are repetitive, stereotyped movements that can disrupt sleep and result in insomnia, non-restorative sleep, and/or daytime sleepiness. Currently, polysomnography is the gold standard and only clinically acceptable means of quantifying PLMS. Leg-worn actigraphy is an alternative method of measuring PLMS, which may circumvent many of the economic and technical limitations of polysomnography to quantify nocturnal leg movements. However, the use of leg actigraphy as a diagnostic means of assessing PLMS has not been systematically evaluated. In this review, the use of leg-worn actigraphy to measure PLMS is systematically evaluated, using both qualitative and quantitative assessment. Findings demonstrate significant heterogeneity among a limited number of studies in terms of type of actigraph utilized, position of the device on the lower extremity, and methods employed to count PLMS. In general, common accelerometers vary in their sensitivity and specificity to detect PLMS, which is likely related to the technical specifications of a given device. A current limitation in the ability to combine data from actigraphs placed on both legs is also a significant barrier to their use in clinical settings. Further research is required to determine the optimal methods to quantify PLMS using leg actigraphy, as well as specific clinical situations in which these devices may prove most useful.

Introduction

Actigraphy, which involves the use of a non-invasive portable device to track movement, is a valuable tool in the clinical practice of sleep medicine. The vast majority of research on actigraphy has focused on wrist-worn devices that track rest-activity patterns, serving as a surrogate measure for periods of sleep and wakefulness. These devices provide acceptably accurate estimates of sleep and wake in healthy populations, as well as in disorders characterized by insomnia and/or hypersomnia, including circadian rhythm disorders [1,2]. In addition, actigraphy often provides useful data in assessing the response to therapy across many of these disorders [1,2].

Recent years have seen significant shifts in the practice of clinical sleep medicine, primarily driven by the ascension of home sleep testing as a viable alternative to in-laboratory polysomnography in the diagnosis of obstructive sleep apnea (OSA) [3]. Out-of-center testing for sleep disorders has the potential benefits of improving delivery of care to patients and decreasing economic costs. Relative to the level of research that has been devoted to the validation of portable monitoring devices to diagnose sleep-related breathing disorders, the use of actigraphy to quantify periodic limb movements of sleep (PLMS), which are repetitive, stereotyped movements that can disrupt sleep and result in insomnia, non-restorative sleep, and/or daytime sleepiness, has received relatively little attention.

The use of actigraphy to measure PLMS has several potential advantages over the current reference standard of polysomnography. Leg actigraphy can provide assessment of limb movements over multiple nights, which may circumvent the diagnostic difficulties associated with high night-to-night variability of PLMS frequency [4]. Also, actigraphy is utilized in the home setting, which may decrease confounding environmental factors (e.g., use of nicotine/alcohol; irregular sleep-wake patterns) that may cause in-laboratory testing to be a poor reflection of the patient's typical experience. Finally, despite the absence of a formal economic analysis, the cost of actigraphy to quantify PLMS is likely to be substantially less than in-laboratory polysomnography, even if repeated over multiple nights to increase diagnostic yield.

The use of actigraphy worn on the lower extremities to measure periodic limb movements has been utilized in large-scale studies to confirm the presence of PLMS [5], and as a measure of treatment

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Abbreviations

AASM	American Academy of Sleep Medicine
DTS	diagnostic test study
EDS	excessive daytime sleepiness
EEG	electroencephalogram
EMG	electromyography
F	female
M	male
NR	not reported
OSA	obstructive sleep apnea
PLM	periodic limb movement
PLMI	PLM index
PLMS	periodic limb movements of sleep
PLMW	periodic limb movements of wake
PSG	polysomnography
RCT	randomized controlled trial
RLS	restless legs syndrome
SRBD	sleep-related breathing disorder
WASM	World Association of Sleep Medicine

response in restless legs syndrome (RLS) [6,7]. However, despite individual studies that have examined the validity of lower extremity actigraphy to detect PLMS, the aggregate evidence for leg actigraphy to quantify PLMS has not been systematically evaluated. Such an empiric evaluation is necessary as it may provide valuable insights into the clinical utility of leg actigraphy, and highlight areas in which further research is required before such devices can be considered standard of care. Thus, the primary objective of this systematic review was to analyze the current literature regarding the validity of lower extremity-worn actigraphy in the quantification of PLMS against the gold standard of polysomnography.

Methods

Criteria for considering studies of this review

Types of participants

Studies that included patients or research subjects who were evaluated with reason to suspect possible periodic limb movements of sleep were included. Studies evaluating both adults and children were included because there is currently no difference in the polysomnographic scoring of PLMS between children and adults according to standard guidelines [8,9].

Forms of interventions

The index test was leg-worn actigraphy and the reference (gold) standard was electromyography (EMG) as part of polysomnography to quantify PLMS. Because there are multiple makes and models of actigraphy that have been used in prior studies, type of device was not a limitation on study consideration for inclusion/exclusion, unless the device in question utilized a form of movement sensor other than an accelerometer. Minimal standards to define polysomnography for this study included measures of neurophysiologic activity: electroencephalogram (EEG), eye movements (electrooculogram), and leg electromyography (EMG).

Outcome measures

The outcome measures of interest were the periodic limb movement index (PLMI; number of periodic limb movements per hour of sleep/recording) and/or total periodic limb movement (PLM) counts derived by simultaneous polysomnography and leg actigraphy, respectively.

Types of studies

All comparison-based studies that examined the use of actigraphy/accelerometry worn on the lower extremities on the same night as a polysomnographic recording were considered. Studies were included that reported comparisons between polysomnographic and actigraphic PLMI and/or total PLM counts, even if this was not a primary aim of the study (e.g., a randomized controlled trial of a pharmacologic treatment would be included, as long as data regarding polysomnography and leg actigraphy from the same night were reported).

Search strategy

Searches were conducted using the following databases: Pubmed, Web of Knowledge, CINHAL Plus, Compendex, and PsycINFO, as well as "waterfall" and "ancestral" searches of related materials. There were no limitations on year of publication or language of article. The following terms were utilized for searches: PAM-RL OR leg actigraph* OR limb actigraph* OR leg acceleromet* OR limb acceleromet* AND polysomnogra*. Both peer reviewed publications and unpublished literature (meeting abstracts, dissertations/theses, etc.) were included, since the likelihood of unpublished studies, and thus publication bias, is higher in studies of diagnostic tests [10]. The author conducted all searches. The last search was performed July 7, 2013.

Eligibility

The following criteria were required for inclusion: 1) simultaneous collection of leg actigraphy and polysomnography with report of PLMI and/or total number of PLM derived from each measure and/or report of relationship between these variables (e.g., correlation); and 2) study of human participants. Specific placement of the actigraphic device could vary across studies (e.g., ankle vs. mid-calf placement), as could type of actigraph, however, these factors were considered in the qualitative and quantitative analysis of the data (see Analysis). Exclusion criteria included: 1) absence of simultaneous polysomnography and leg actigraphy; 2) use of non-human subjects or simulation-based data; 3) failure to report PLMI/PLM counts from polysomnography and/or leg actigraphy or their correlative relationship; and 4) use of out-of-center measurement device to determine PLMI other than actigraphy (e.g., mattress pressure sensor). All articles were screened for inclusion by the author, unblinded to manuscript authorship.

Data extraction

The author extracted all data (unblinded). Extracted data included: author/journal, year of publication, type of study, make/model of actigraphy, actigraphy settings, placement of device (e.g., single leg vs. bilateral; ankle vs. dorsum of foot), method for calculating PLMI, number and demographics (ages, sex, co-morbid disorders, etc.) of subjects, findings (e.g., sensitivity, specificity), cut-off point used in dichotomous testing to define a clinically significant number of PLMS (e.g., PLMI >5, 10, 15/h), and level of evidence (Table 1). Level of evidence was determined by the primary author according to the Centre for Evidence Based Medicine (CEBM) guidelines for diagnostic studies [11].

Assessment of study quality

Study quality was assessed (unblinded) by the author using the standards of the quality assessment of diagnostic accuracy studies, version 2 (QUADAS-2) [12]. Ratings of each study using QUADAS-2 are presented as a resource/reference to the reader, but were not used in the weighting of quantitative data (see Analysis).