

Home Sleep-Monitoring Devices: Bridging the Periodic Limb Movement in Sleep Information Gap

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Abstract

The prevalence of periodic limb movement in sleep (PLMS) in patients with Restless Legs Syndrome is estimated between 80 to 90%, >34% of the population over 60 years of age and 36% of healthy subjects were found to have a PLMS index >5 event per hour of sleep. PLMS can be associated with sleep breathing disorders, insomnia, narcolepsy, and REM Behavior disorder. Its prevalence in the general population is unknown. Home sleep-monitoring devices (HSMD) could be used to derive some consensus on the clinical and non-clinical characteristics of PLMS. There is need to derive age-adjusted normative values for PLMS, assess their clinical significance when presenting as comorbidities, phenotyping the genetic variants and tracking the pathophysiology along a continuum to determine signs and symptom changes from pre-clinical to clinical relevance. This article provides information on why and how HSMD is the logical approach in bridging the clinically relevant information gap associated with PLMS. It discusses future directions to be taken in utilizing HSMD to objectively measure PLMS and determine their effect on sleep quality.

Keywords: Home sleep monitoring device; Periodic limb movement in sleep; Technology

Introduction

In-laboratory polysomnography (PSG) remains the 'gold standard' to evaluate periodic limb movements in sleep (PLMS). With continued reliance on PSG, challenges persist to gain better understanding of the longitudinal changes associated with PLMS and the effect on sleep quality. PLMS are not easily recognized in clinical practice [1]. This suggests solutions are needed to facilitate clinician identification and diagnosis of PLMS. Home sleep monitoring devices (HSMD) provide novel strategies to record multiple physiological signals including sleep and transmit them in real time that could improve clinical recognition and bridge some of the PLMS knowledge gap. An extensive review of HSMD measuring or having the potential to measure sleep was recently published [2].

Why are HSMD the Tools to Assess PLMS?

PLMS are very common in older adults [3]. The prevalence of PLMS is estimated to be >80% in patients with restless legs syndrome (RSL), [4] >34% in the population over 60 years old, [5] and 36% of healthy subjects were reported to have a PLMS index >5 events per hour of sleep [6]. The PLMS incidence increases with age. It appears to be a formidable and expensive task to perform the required testing using in-lab PSG.

Recording and tracking movement activity in the patient's home seems to be the logical approach to address and assess the high PLMS prevalence in the aged population. Integration of newly reported indices into HSMD have the potential to provide valuable clinical information on the various PLM phenotypes, [7-10] genotypes [11,12] and efficacy of pharmacological interventions [13].

HSMD measuring PLMS might lead to enhanced understanding of the pathophysiological mechanisms, clinically useful diagnostic criteria and effective treatments.

The clinical utility of limb-worn devices using Actigraphy to measure a pharmacologic response based on the PLM index in RLS patients showed some reliability [10]. Because PLMS can be comorbid with other sleep disorders (i.e. OSA, [4,5] narcolepsy, [14] rapid eye movement behavior disorder [15] their association to and exclusion from other potential causes of a sleep complaint needs to be determined in conjunction with other simultaneously recorded biological signals. HSMD that record multiple biological signals over consecutive nights might be a better alternative for assessing PLMS clinical significance than a single-night PSG, since consecutive recordings would capture night-to-night variability [10] and time-of-night PLM patterns [16].

How to Bridge the PLMS Information Gap?

The prevalence of periodic limb movement in sleep (PLMS) in patients with Restless Legs Syndrome is estimated between 80 to 90%, >34% of the population over 60 years of age and 36% of healthy subjects were found to have a PLMS index >5 event per hour of sleep. PLMS can be associated with sleep breathing disorders, insomnia, narcolepsy, and REM Behavior disorder. Its prevalence in the general population is unknown. Home sleep-monitoring devices (HSMD) could be used to derive some consensus on the clinical and non-clinical characteristics of PLMS. There is need to derive age-adjusted Currently, a major emphasis within clinical sleep medicine is home sleep testing (HST) devices for evaluating sleep apnea. Our understanding of periodic limb movement disorder which has repetitive movements primarily occurring during non-rapid eye movement sleep, needs further elucidation. PLMS can have a negative impact on sleep quality and health similar to sleep apnea disruption in

some cases. PLMS might be easily identified using some of the currently available HSMD by integrating software modifications.

Implementing algorithms with American Academy of Sleep Medicine (AASM) criteria [17] into HSMD analyses, PLMS could be objectively measured based on the number of movements. Patient's with a subjective complaint of unrefreshing sleep and suspected of having PLMS could be tested in their home sleeping environment without recording brain activity. A similar awareness spawned the sleep apnea HST market.

Available 'multi-signal' consumer HSMD have the potential to provide objective sleep measures, a PLMS index and some associated sleep physiological perturbations. HSMD algorithms would need to utilize criteria similar to those typically acquired from the anterior tibialis muscle surface electrode. The Criteria includes movement duration of 0.5 – 5 seconds, separated by intervals of 4-90 seconds. [4] The PLM event amplitude in sleep is required to be at least 25% of the voluntary leg movement obtained during Wake bio-calibrations. PLM events meeting criteria are counted to derive a PLM index (number of events per hour of sleep), although the clinical significance of this parameter is questionable [3]. Some authors suggest the time intervals between PLM events may have more clinical meaning [4,7,14,18-20]. HSMD that report event time intervals and autonomic nervous system (ANS) changes could have clinical importance since ANS responses typically accompany electroencephalogram (EEG) arousals.

Not all PLMS are associated with detectable EEG arousals [21] however, autonomic activity increases of systolic and diastolic blood pressure, [22] respiration and heart rate [21,23,24] have been reported. HSMD measuring sleep, recording respiration and heart rate together with actigraphy could provide HST of PLMS in a similar manner to HST devices for sleep apnea that do not utilize EEG data (i.e. Type 3 category devices). [25] Optimally, those devices assessing sleep based on autonomic measures of heart and respiration rates with integrated actigraphy would be ideally suited to provide clinically valuable PLMS data.

What is Needed?

Research studies are needed to correlate thoracic actigraphy with anterior tibialis movement, since the multi-signal HSMD often utilize chest worn tri-axial accelerometers to measure activity. Current reports indicate such a correlation is feasible since myoclonus from neck, 6 hips and upper extremities 4 have been reported using EMG surface electrodes. An Actigraphy index must show high correlation to the PLM index and the algorithms should provide calculation of the periodicity between events. Evidence of leg movement (LM) periodicity obtained from the PSG ECG signal was published in a case report that showed LM and CSA periodicity occurred at different frequencies [26] using cardiopulmonary coupling analysis [27].

It is logical to envision obtaining PLM activity and the periodicity index from a thoracic-based signal. Activity measures from a chest-worn accelerometer could be reported similar to anterior tibialis derived indices, using both frequency and time domain [14]. HSMD with an integrated snore detection signal could potentially identify associations between sleep quality, upper airway resistance, increases in heart rate and activity to ascertain comorbid sleep breathing disorder with PLMS [28].

Challenges remain to present the information from consumer devices into clinically meaningful data. These include but are not

limited to pre-recording calibration of LM although trunk source background activity might be sufficient to establish a 'noise' baseline. Similar to the AASM approach, an algorithm could use digital filters and an activity baseline threshold value within the floating analysis windows to measure events exceeding background noise. Event amplitude and duration of identified chest-derived activity events will need to be confirmed in a clinical study relative to standard PSG LM scoring rules.

Summary

Characterization of LM using HSMD is the next logical phase to enhance our understanding of PLM neurophysiologic features, biomarkers, phenotypes, genotypes and comorbidities as well as treatment efficacy. Tracking PLM pathophysiology along a continuum to determine signs and symptom changes from pre-clinical to clinical relevance using HSMD is a reasonable approach. Consumer products with software modifications might provide the cost effective testing solution to determine the effect of PLMS on sleep quality. Furthermore, objective measures of sleep quality may provide thresholds to create categories that facilitate communication and clinical decision-making in patients with PLMS. These hypotheses remain to be investigated.

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