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Periodic limb movement screening as an additional feature of Emfit sensor in sleep-disordered breathing studies

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ABSTRACT

Background: The standard method for recording periodic limb movements is anterior tibialis electromyography (EMG) but other methods are also used. A new movement sensor Emfit (ElectroMechanical Film) provides information about sleep-disordered breathing but also shows movements in bed. The aim of the study was to investigate the usability of a small Emfit sensor in revealing periodic movements.
Methods: Twenty seven consecutive patients were studied. Periodic movements in EMG and Emfit were scored blindly and periodic leg movement index (PLMI) for EMG and periodic movement index (PMI) for Emfit were counted. Spearman's correlation coefficient was used to assess the relationship between Emfit data and EMG results. Sensitivities and specificities were computed for PLMI and PMI levels of 5 and 15 movements/h. Additionally, receiver operating characteristic (ROC) curves were derived and the area under the curve (AUC) was calculated.
Results: The Spearman's correlation coefficient between the PMI of Emfit and the PLMI of EMG was 0.87. The sensitivity of the Emfit sensor to detect periodic limb movements was 0.91 at the level of 5 movements/h and 0.73 when the cut-off level was 15 movements/h. The specificities were 0.75 and 1.00, respectively. AUC in ROC analysis was 0.96 and 0.98 in the levels of 5 and 15 movements/h.
Conclusions: The results suggest that the Emfit sensor might be suitable for screening of periodic limb movements even if the sensor is placed under the thoracic area of the patient in sleep-disordered breathing studies.

1. Introduction

Periodic limb movements (PLMs) are relatively common findings in polysomnograms. Around 70–90% of restless legs syndrome (RLS) patients have PLMs in their sleep recordings (Montplaisir et al., 1997). PLMs are quite common also among snorers and obstructive sleep apnea syndrome (OSAS) patients (Coleman et al., 1980; Chervin, 2001; Haba-Rubio et al., 2005) and during continuous positive airway pressure treatment (Fry et al., 1989). Besides, PLMs can be found in polysomnograms without other findings (Bixler et al., 1982; Polo-Kantola et al., 2001; Carrier et al., 2005).

PLMs are defined to last from 0.5 to 10 s and occur in a series of at least four movements at intervals of 5–90 s (Zucconi et al., 2006). The standard method for recording PLMs is the anterior tibialis electromyography (EMG) (Zucconi et al., 2006), but many other methods, for instance activity monitors, piezoelectric devices, stretch sensors, video etc. are used (Hening, 2004). Actigraphs are used increasingly for PLM studies and recent standards for recording and scoring PLMs also include guidelines for using motion detector systems for activity monitoring of leg movements (Zucconi et al., 2006). In our previous study we found that the static-charge-sensitive bed (SCSB, Alihanka et al., 1981), which is widely used in Finland to monitor nocturnal breathing, is also suitable for detecting periodic movement activity (Rauhala et al., 1996). Lately in many sleep laboratories the SCSB has been replaced by a new movement sensor, Emfit (ElectroMechanical Film) because it is flexible and can be used with a regular mattress.

We use Emfit as part of polysomnography and our ambulatory cardio-respiratory polygraphy systems. Emfit is elastic, permanently charged ferro-electret plastic film that converts mechanical stress into proportionate electrical charge and conversely, it mechanically expands when voltages of opposite polarities are applied (Paajanen et al., 2000). When used to study sleep-disordered breathing the small Emfit sheet is placed under the

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thoracic area. Emfit has been shown to be useful in the analysis of breathing movements (Alametsä et al., 2003) and we have noticed that so called SCSB spiking phenomenon, which is related to partial airway obstruction during sleep, is also present with Emfit (Alametsa et al., 2006). We have also previously shown that a prolonged spiking phenomenon in the Emfit sensor is related to an increase in transcutaneous carbon dioxide and flow limitation pattern in a nasal pressure transducer (Rauhala et al., 2007).

Emfit is a highly sensitive movement sensor and also distant movements in limbs cause changes in the Emfit signal even if the sensor is placed under the thoracic area. We have observed in routine clinical work that in many patients periodic limb movements induce pronounced stereotyped deflections in the Emfit signal. Therefore the aim of the present study was to investigate the usability of a small Emfit sensor in revealing periodic movements.

2. Subjects and methods

2.1. Subjects

Twenty seven consecutive patients (18 men and 9 women) referred to the sleep laboratory of the Pirkanmaa Hospital District volunteered to participate in this study. All the subjects gave their informed consent. The study was approved by the Ethical Committee of the Pirkanmaa Hospital District. The reasons for referrals were suspicion of restless legs syndrome for five patients, control of continuous positive airway pressure treatment for four patients and possible sleep-disordered breathing for 18.

2.2. Methods

Embla N7000 and Somnologica software (Medcare, Iceland) were used as a recording system. The recording montage consisted of six EEG derivations (Fp1-A2, Fp2-A1, C3-A2, C4-A1, O1-A2, O2-A1), two EOG channels and submental electromyography, electrocardiogram, nasal pressure transducer, thermistor, thoracic and abdominal respiratory movements, body position, blood oxygen saturation and pulse by pulseoximetry, anterior tibialis muscle electromyography and the Emfit signals. The sampling rate of 1 Hz was used for pulseoximetry and 200 Hz for all other parameters.

In the present study an Emfit sensor with dimensions of 32 cm × 62 cm was placed below a bed-sheet under the thoracic area of the sleeping patient (Fig. 1). Emfit was connected to a bipolar channel of the recorder. The signal was amplified and filtered into the high frequency (6–16 Hz) band analogously with the SCSB filtering (Polo, 1992; Kirjavainen et al., 1996).

Fig. 1. Emfit movement sensor placed on an ordinary mattress below a bed-sheet.

2.3. Visual analysis

The recordings were scored into sleep stages according to the Rechtschaffen and Kales (1968) criteria. Periodic movements in EMG and Emfit channels were scored blindly and independently by two neurophysiologists using the time window of 4 min/screen. Scorings of EMG recordings were performed using the World Association of Sleep Medicine (WASM) standards (Zucconi et al., 2006). The same principles were also used in the Emfit scorings following the leg activity monitoring standards in the WASM guidelines. PLMs were defined as repetitive muscle jerks lasting from 0.5 to 10 s, separated by an interval ranging from 5 to 90 s, with an EMG amplitude rise of 8 μV above resting level, organized in series of 4 or more consecutive leg movements. In the Emfit scoring the threshold of movement detection was set as double the basic Emfit signal amplitude, which seems to correspond well with the anterior tibialis EMG amplitude increase of ≥8 μV (Fig. 2). After the independent movement scorings the two neurophysiologists formed together the EMG and Emfit consensus scorings which were used in further analyses.

To compare with Emfit the movements in the right and left EMG channels were combined and bilateral movements were counted as one. The movements occurring on the two sides were considered bilateral when they were overlapping or separated by less than 0.5 s (Zucconi et al., 2006). The total number of single and periodic movements were tabulated and the periodic limb movement index (PLMI) for EMG and the periodic movement index (PMI) for Emfit

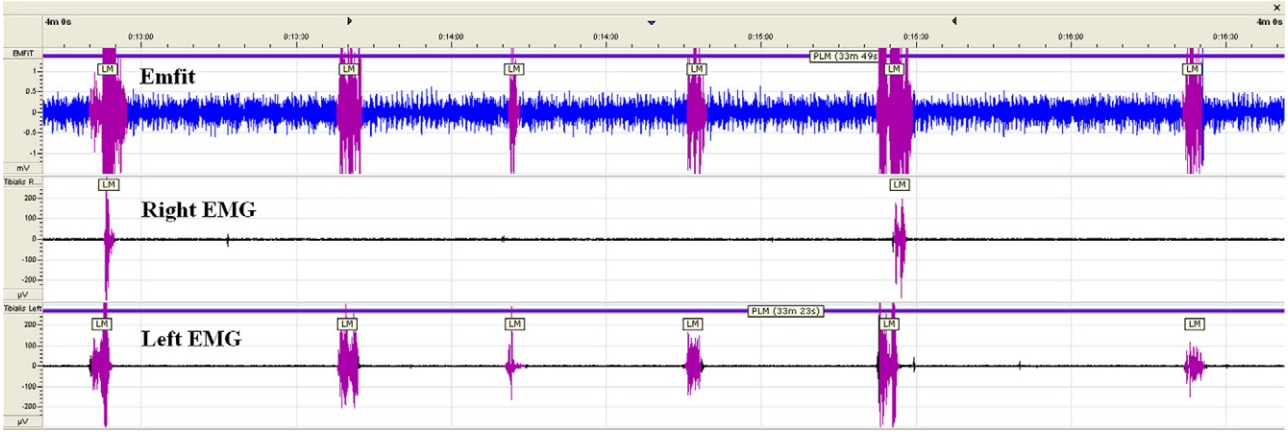

Fig. 2. An example of a 4 min polysomnography page presenting periodic movements in Emfit and left EMG channels. Two simultaneous single movements in right EMG channel. Durations of the movements in this sample were 1–7.5 s.