

A Novel Smartphone Application Can Detect Periodic Limb Movements

Rashmi Bhopi, David Nagy, Daniel Erichsen,
Department of Pediatrics
St. Barnabas Hospital
Albert Einstein College of Medicine, Bronx, NY, USA

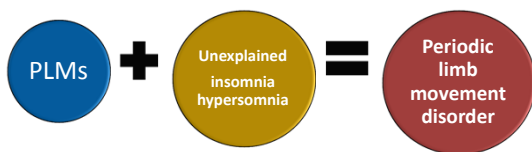


Introduction

- Periodic limb movements (PLMs)
 - unconscious
 - involuntary
 - repetitive movements
 - of lower extremities that occur in sleep
- Jerky movements



Introduction



- PLMD
- 80% of patients with Restless leg syndrome (RLS) have PLMs



Introduction

- PLMs are scored (American academy of Sleep)
 - 4 consecutive movements
 - Duration of 0.5- 5 seconds
 - Separated by 5-90 seconds
 - 0.8 mV above resting voltage
- PLM index
 - > 5 PLMs per hour of sleep = pathological



Introduction

Treatment for PLMD :

- Dopaminergic agonists
- Benzodiazepines
- GABA agonists



Introduction

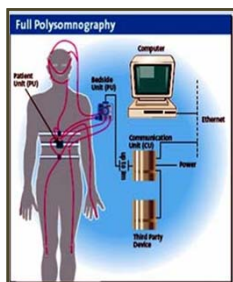
- Prevalence estimated to 4-11%
- Diagnostic challenge



Introduction

Diagnostic gold standard :

Polysomnographic evaluation +
bilateral anterior
tibial electromyography
(BATEMG)



Introduction

Limitations:

- Hospital environment
- One or several nights
- Uncomfortable
- Man-power
- Expensive



Introduction

Actigraphy



Introduction

Limitations:

- Expensive
- Requires interpretation of data



Aim


To develop a limb movement sensing application (LMSA) for a smart phone using the built-in accelerometer



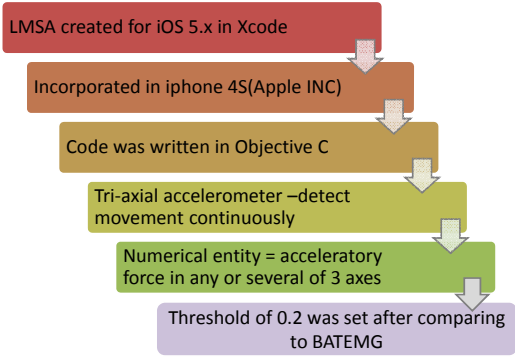
Aim

Objectives:

- Remote diagnosis and consultation
- Unlimited follow up
- Reduce cost and labor



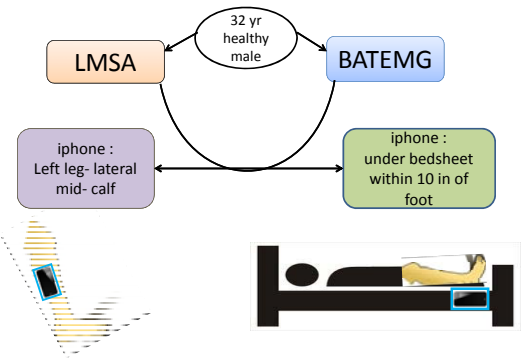
Methods- programming



```

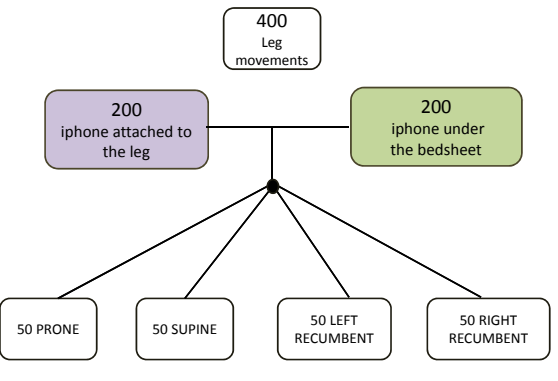
    graph TD
      A[LMSA created for iOS 5.x in Xcode] --> B[Incorporated in iPhone 4S (Apple INC)]
      B --> C[Code was written in Objective C]
      C --> D[Tri-axial accelerometer - detect movement continuously]
      D --> E[Numerical entity = acceleratory force in any or several of 3 axes]
      E --> F[Threshold of 0.2 was set after comparing to BATEMG]
    
```

Methods- Data acquisition



The diagram shows a central node for a "32 yr healthy male" connected to two methods: "LMSA" and "BATEMG".

- LMSA** is associated with an "iphone : Left leg- lateral mid- calf" (illustrated with a leg diagram).
- BATEMG** is associated with an "iphone : under bedsheets within 10 in of foot" (illustrated with a person in bed).



```

    graph TD
      A[400 Leg movements] --> B[200 iPhone attached to the leg]
      A --> C[200 iPhone under the bedsheets]
      B --> D[50 PRONE]
      B --> E[50 SUPINE]
      C --> F[50 LEFT RECUMBENT]
      C --> G[50 RIGHT RECUMBENT]
    
```

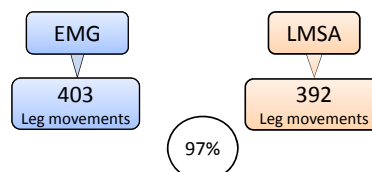
Methods

Scoring:

- BATEMG data scored as per American Academy of Sleep Medicine guidelines
- Compared to LMSA auto scored data



Results



No difference in the mean number of recorded leg movements
(50.4 +/- 0.51 vs 49.0 +/- 3.7 $p=0.3$)

Results

Positions	Iphone attached to leg		Iphone under the bedsheet	
	LMSA 196	EMG 201	LMSA 196	EMG 202
Prone	49	50	41	51
Supine	50	50	51	50
Left Recumbent	47	51	53	50
Right Recumbent	50	50	51	51
<i>p value</i>	0.15		0.6	

Discussion

- LMSA accurately detects periodic limb movements
- Calculates PLM index

Uses:

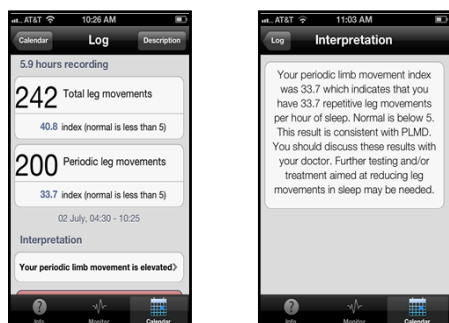
- Screening for PLMD
- Follow up of patients after initiation of treatment



Discussion

Advantages

- Remote monitoring/ self monitoring at home
- Inexpensive
- Easy to use/ interpret
- No other equipment needed



Thank you