

## Role of Actigraphy in the Diagnosis of Sleep Disorders

**Aman Gupta\***

*Sleep Medicine Graduate Reading, Nuffield Department of Clinical Neurosciences, University of Oxford, England, Visiting Fellowship fMRI- A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Harvard Medical School Boston, USA*

**\*Corresponding Author:** Aman Gupta, Sleep Medicine Graduate Reading, Nuffield Department of Clinical Neurosciences, University of Oxford, England, Visiting Fellowship fMRI- A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Harvard Medical School Boston, USA.

**Received:** March 09, 2018; **Published:** March 28, 2018

### Abstract

**Introduction:** Good quality and optimal quantity of Sleep is of key importance as the derangement in the same can lead to the further challenges in various metabolisms and lead to multiple Sleep related disorders. One of the key aspect to diagnose and further manage the Sleep disorders is measurement of the Sleep. Polysomnography is considered as Gold standard for the Sleep measurement, however secondary to its operational and infrastructural challenges, other measures which are more user friendly need to be evaluated. In the current review, one the movement based Sleep tracking device is being evaluated. The Sleep assessment and measurement based on Actigram is termed as Actigraphy.

**Methodology:** For the current review multiple original studies and review articles were considered. The role of Actigraphy was compared with the Gold Standard of Sleep measurement i.e. Polysomnography. Comparison of actigraphy and other commercially available tools like Sleep diaries and WATCH PAT instrument was done. This instrument comprised of Actigram, Pulse oximeter and peripheral artery tonometer.

**Results:** In this review it was observed that Actigraphy is a great tool with respect to the Sensitivity, accuracy and user friendliness when compared with the PSG. However, the specificity of actigraphy was much lower than significant levels. This signifies that Actigraphy need to be combined with other tools like Sleep diaries to get more specific results with respect to the Sleep measurement.

**Conclusions:** It can be concluded that as a device Actigraphy has its own importance being sensitive and accurate, however lacks the specificity. Overall, when combined with other instruments like PSG, Sleep diaries and other tools actigraphy can be really instrumental in both Sleep research and Sleep Medicine.

**Keywords:** Actigraphy; Sleep Disorders; Actigram

### Abbreviations

AHI: Apnoea/Hypopnoea Index; EOG: Electrooculography; EMG: Electromyography; EEG: Electroencephalography; ICSD-3: The International Classification of Sleep Disorders-Third Edition; PSG: Polysomnography; PAT: Peripheral Arterial Tonometry

### Introduction

Sleep is one of the important requirement of the Humans and other species. Lack of persistent quality sleep can lead to multiple health challenges secondary to derangement in the metabolisms pertaining to endocrine system, carbohydrate, hepatic etc [1].

Therefore it is utterly important to understand about the type of disorders which are related to the lack of prolonged good quality sleep, their provisional diagnosis, methods and differential diagnostic approaches including the different kinds of tools available to support the Clinical diagnosis and Research in this domain.

Further, understanding positives and negatives of these technologies and existing methods like sleep diaries etc. need to be evaluated as a whole or as a group of diagnostic procedures to establish the correct differential diagnosis of the disease and hence recommend effective treatment.

**Categorization of the Sleep Disorders**

Sleep disorders can be classified into various categories as per different criteria. ICSD-3 is one of the key diagnostic classification of the Sleep disorders and categorize the same as:

1. Insomnia,
2. Sleep-related breathing disorders,
3. Central disorders of hyper somnolence,
4. Circadian rhythm sleep-wake disorders,
5. Parasomnias and
6. Sleep-related movement disorders [2].

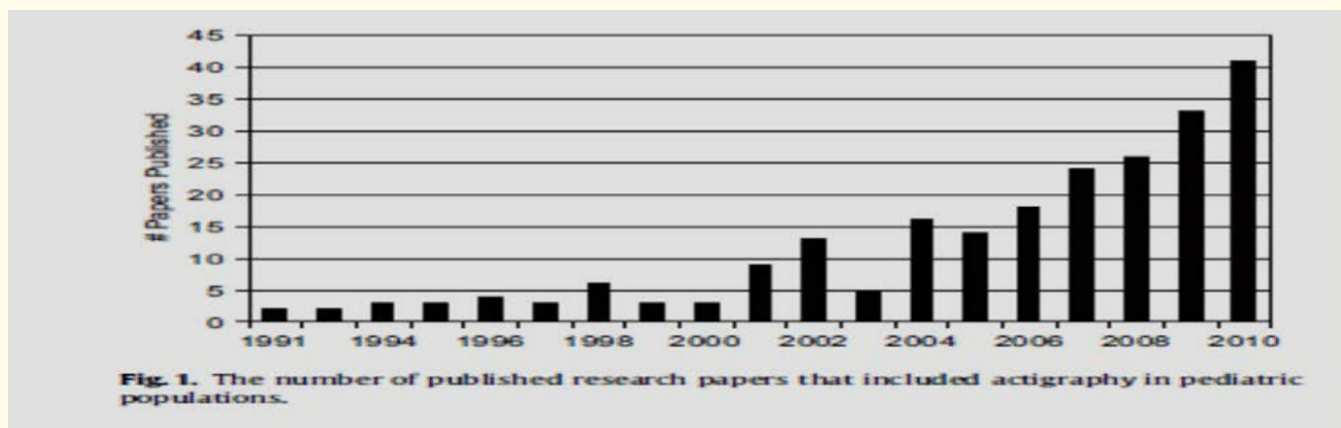
**What are the currently available techniques for the diagnosis and further management of various Sleep Disorders?**

Currently there are multiple methods/technologies to help provisional diagnosis and differential diagnosis of the Sleep disorders. Actigraphy, Sleep Diaries, Commercial Devices and Polysomnography are most known [3-10].

**Description of the Individual Methods/Devices for recording, observing sleep patterns**

**Actigraphy**

Actigraphy is a movement/activity detection based portable instrument available in different forms most popular of which is wrist watch type actigraph. Basic concept of used by actigraphy instrument is measurement of the movements based on which corresponding sleep pattern can be estimated. Actigraphy is an objective method to be used in the Sleep disorder diagnosis and research [11]. There has been significant increase in the usage of Actigraphy as a tool specially in Paediatric research and sleep studies as Polysomnography is really troublesome in case of paediatric population [11].



**Fig. 1.** The number of published research papers that included actigraphy in pediatric populations.

**Figure 1:** Demonstrates the use of actigraphy as gained lot of popularity in last 2 decades or so as indicated by the increased number of publications using actigraphy as a tool as compared to Polysomnography in Paediatric subjects [11].

**Sleep Diaries**

Sleep diary can be printable paper version or a soft computerized which is designed to collate the detailed information on the sleep duration, quality, pattern etc [3]. The diary can have questions like what time you went to bed, how much time you spend trying to go to sleep etc.

**Polysomnography**

Polysomnography would require either sleep lab setting or portable device which helps to get information pertaining to the duration, quality, pattern and behavioural challenges during sleep.

It is complex device which will require significant expertise in operations and interpretation of the reports. It comprises of multiple channels and work of Electrophysiological grounds and measures the Eye movement (EOG), muscle movement (EMG) and the brain activity (EEG) [12].

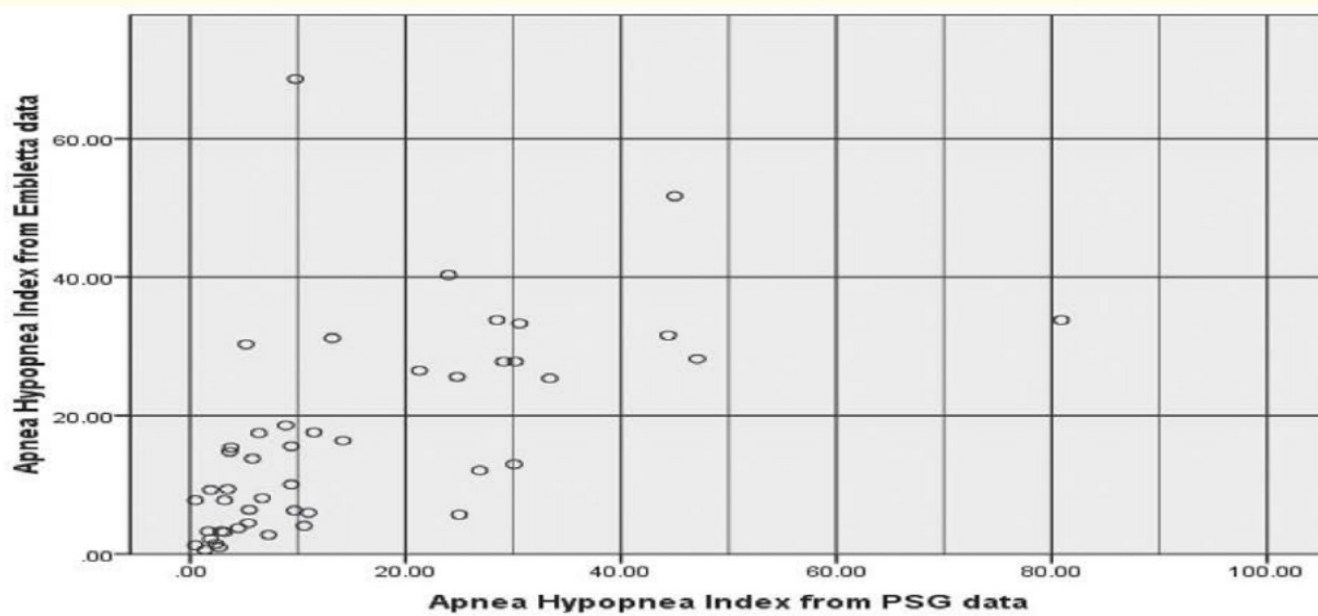
**Polysomnography can be used for the diagnosis of the following disorders [5]**

- Sleep related breathing disorders
- Narcolepsy
- Parasomnias
- Sleep related seizure disorders
- Restless legs syndrome
- Periodic limb movement sleep disorder
- Depression with insomnia
- Circadian rhythm sleep disorders” [5].

In a study conducted by Van Der Kloet., *et al.* [13] Polysomnography role in the evaluating the association of dissociation disorders like memory loss in insomnia patients (n = 46) was investigated and it was found that the patients with insomnia had challenges pertaining to the memory loss as well and these symptoms are related to the EEG signals received.

Polysomnography can be done in a sleep lab setting and portable machine is also available for which there is no specific requirement to be in the sleep lab and can be done at residence as well [14].

In a study conducted by Gjevre., *et al.* a total of 41 women with sleep apnoea received polysomnography and portable polysomnography as intervention and accuracy of both the methods was compared. Both the methods were found to be equally good as indicated by the apnea/hypopnea index (AHI) between the two groups.



**Figure 2:** Pearson’s correlation 0.582 (P < 0.001). of AHI values from PSG and portable SG revealed significant association between the two [14].

**Comparison of the Actigraphy with other currently available techniques**

**Actigraphy versus Sleep Diaries**

Historically Sleep diaries have been used in isolation and proven effective, however with the evolution of technologies like actigraphy, former has become one the key complementing techniques to diagnose the Sleep derangement [15].

Sleep diaries are much cost effective and can have detailed information on the sleep quality, pattern and behaviour however the actigraphy is more related to the recording the movements or acceleration with some added benefits in different models. Sleep diaries are however more challenging in the children and he infant populations, however detailed data can be obtained from them.

Of late scientists and Clinicians have evolved a better approach to use the two in conjunction as complementary tool to each other to have more accurate, validated and specific results in understanding the sleep/wake derangement [15].

**Actigraphy versus PSG [11,16]**

Polysomnography is considered as gold standard in measuring the sleep conditions [16]. Actigraphy has gained popularity over last few years specifically in special populations like Paediatrics and being portable and no requirement being indoor management like in sleep laboratory of a hospital. It is also more user friendly as compared to the Polysomnography as the later has multiple channels and electrodes to be placed and the former is available in wrist watch like instruments.

Because of its upcoming popularity and usage a comparison study was done to compare and validate actigraphy versus the Polysomnography in the measurement of sleep and wakefulness.

In a study (n = 77) done in a sleep laboratory setting validity, sensitivity and specificity of the Wrist watch type actigraphy was compared with the Polysomnography [16]. Total duration on the bed was 8.5 hours excluding in those cases with sleep restriction. For sensitivity Epochs (30 secs) were used, other measures for the specificity (Epochs correctly assigned as wake) and accuracy (correct categorization of the epochs) were used in comparison with the Polysomnography.

Table 1 [16] using 30 secs Epochs when Actigraphy was compared with the PSG, the former was found to be accurate to 84%, Sensitive 95% and Specific to a level of 28.5%. The results refer to one major challenge with Actigraphy is specificity when compared to the Gold Standard test polysomnography.

Original Timing					
		Actigraphy			
		“Sleep”	“Wake”	Accuracy = 0.848	
PSG	Sleep	186,889	8,794	195,683	Sensitivity = 0.955
	Wake	26,572	10,594	37,166	Specificity = 0.285
		213,461	19,388	232,849	
Modified Timing (temporally aligned PSG and actigraphy files used for all analyses)					
		Actigraphy			
		“Sleep”	“Wake”	Accuracy = 0.863	
PSG	Sleep	188,746	6,937	195,683	Sensitivity = 0.965
	Wake	24,920	12,246	37,166	Specificity = 0.329
		213,666	19,183	232,849	

**Table 1:** “Epochs of actigraphy and polysomnography (30-second)”

In a retrospective study actigraphy role in the evaluation of the primary insomnia was investigated to differentiate between the insomnia patients (n = 151) and subjects with no sleep challenge (n = 342) [9].

Multiple aspects observed in the actigraphy were: “time in bed, sleep-onset latency, total sleep time, wake after sleep onset, sleep efficiency, number of awakenings, terminal wakefulness, fragmentation index and mean motor activity. Along with this circadian indices used were: inter daily stability and intra daily variability” [9].

Table 2 [9] in the table below the results shown were either secondary to direct motor activity as recorded by the actigram or data was recorded based on the algorithms for wake sensitivity viz: low, medium, high and auto. Table very clearly indicates that the insomnia patients were in bed significantly higher time when compared with the control group indicating difficulty to fall asleep. Similarly, sleep onset latency, mean motor activity and fragmentation index were significantly high in the Insomnia group.

	Control group	Insomnia group	F	P value
Bed time <sup>a</sup>	24:11 ± 1:19	23:50 ± 1:12	1.62	n.s.
Get up time	07:53 ± 1:16	08:15 ± 1:25	30.01	< 0.00001
TIB	462.91 ± 48.98	505.54 ± 64.07	93.73	< 0.00001
SOL	9.27 ± 7.48	16.05 ± 14.71	33.57	< 0.00001
MA	16.97 ± 6.78	27.30 ± 17.69	45.10	< 0.00001
FI	28.98 ± 8.97	37.33 ± 16.88	37.49	< 0.00001
IS	.53 ± .12	.51 ± .13	13.06	n.s.
IV	.85 ± .21	.81 ± .24	.29	n.s.
Low_TST <sup>b</sup>	413.84 ± 45.59	425.49 ± 69.72	14.49	n.s.
Low_NWAK	23.52 ± 11.20	26.56 ± 9.74	23.13	< 0.00001
Low_WASO	35.79 ± 14.21	57.72 ± 32.08	115.04	< 0.00001
Low_TWAK	3.88 ± 3.24	6.28 ± 6.67	14.08	n.s.
Low_SE	89.46 ± 3.75	84.18 ± 8.63	72.84	< 0.00001
Medium_TST	389.86 ± 48.82	396.24 ± 70.93	6.03	n.s.
Medium_NWAK	28.91 ± 10.51	31.56 ± 8.87	20.58	< 0.00001
Medium_WASO	58.62 ± 20.88	87.12 ± 39.77	115.08	< 0.00001
Medium_TWAK	3.86 ± 3.23	6.12 ± 6.11	13.44	n.s.
Medium_SE	84.57 ± 4.88	78.35 ± 10.01	71.55	< 0.00001
High_TST	363.73 ± 48.70	364.68 ± 71.53	2.27	n.s.
High_NWAK	30.45 ± 9.54	32.40 ± 7.97	15.01	n.s.
High_WASO	84.88 ± 26.48	118.75 ± 45.92	115.79	< 0.00001
High_TWAK	3.99 ± 4.16	6.06 ± 6.09	8.24	n.s.
High_SE	78.91 ± 5.76	72.12 ± 10.99	68.76	< 0.00001
Auto_TST	414.68 ± 53.10	433.34 ± 66.85	24.84	< 0.00001
Auto_NWAK	21.94 ± 9.06	24.25 ± 8.14	19.94	< 0.00001
Auto_WASO	32.62 ± 12.09	50.04 ± 25.08	101.74	< 0.00001
Auto_TWAK	3.87 ± 3.24	6.09 ± 6.10	12.63	n.s.
Auto_SE	90.13 ± 3.14	85.61 ± 7.09	69.84	< 0.00001

**Table 2:** Sleep measures (means and standard deviation) for insomnia and control group. The Table is divided into 2 sections.

Abbreviations: n.s.: Not Significant; TIB: Time in Bed (Min); SOL: Sleep-Onset Latency (min); MA: Mean Motor Activity (Number of Movements in 1 Epoch); FI: Fragmentation Index; IS: Interdaily Stability; IV: Intradaily Variability; NWAK: Number of Awakenings; WASO: Wake After Sleep Onset (min); TWAK: The Time (min) between Sleep End and Get Up Time; SE: Sleep Efficiency.

a: In the first section, sleep parameters derived from any sleep algorithm are grouped: bedtime refers to the moment at which subjects go to bed and switch off the light, and get up time refers to the moment at which subjects wake up for the last time in the morning.

b: In the second section, sleep measures for each wake sensitivity threshold (low, medium, high, and auto) are reported.

Actigraphy and other commercial devices

Actigraphy versus the Oximetry

There are certain devices in the market which are actually a combination of Oximeter and Actigraph.



Figure 3: "Watch PAT" Device which acts as Actigram, Oximeter and the peripheral artery tonometer [17].

In a study conducted by Penzel, *et al.* [17] a new device which combined "Watch PAT" Device which acts as Actigram, Oximeter and the peripheral artery tonometer was used for the detection of sleep apnoea in the patients. The new device had a wrist watch type assessor along with two finger sensors.

Out of the 21 patients who were investigated with the new device and the cardiorespiratory PSG in the control arm, 17 assessments could be done completely and it was found that there was significant correlations between both the groups ( $r = 0.89, p < 0.01$  refer figure 4) and "Watch PAT".

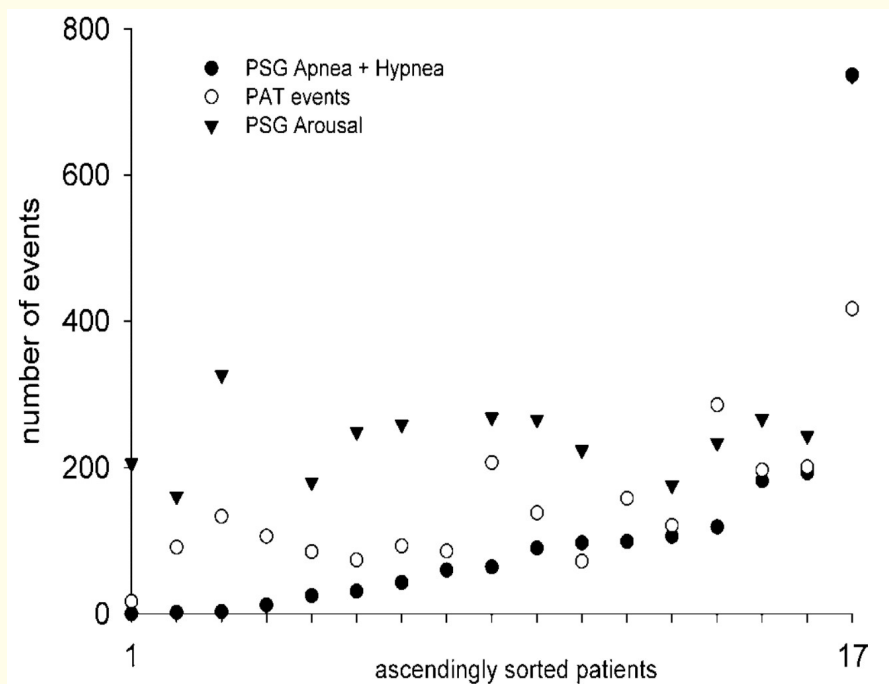
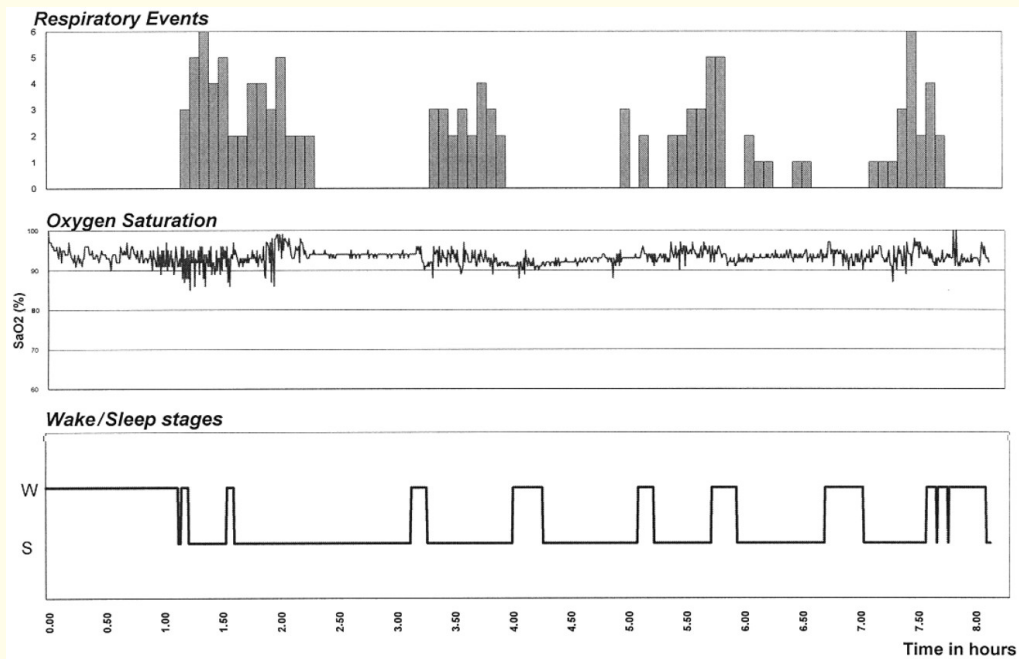


Figure 4



**Figure 5:** The figure represents the outcomes of the PAT events, oxygen saturation readings and the sleep pattern as indicated by the WATCH PAT instrument [17].

**Discussion and Conclusion**

Actigraphy has become one of the important diagnostic tool in the field of Sleep medicine and research. However there are both pros and cons of the device being more objective specially as it movement based tracking device owing to which it can misinterpret wakefulness as being asleep.

When compared with PSG actigraphy showed significant sensitivity and however lacked on the grounds on being specific when sleep wake patterns and quality of sleep was assessed [10,16].

Though the actigraphy is used in paediatric and infant populations with some success [11], however overall role of Actigraphy in cases like significant health challenges like Parkinson’s disease etc. is not that promising [10].

There have been also certain challenges associated with the algorithms of the actigraphy with respect to the validity of the same, saying that more deep diving is required to be done to make robust protocols pertaining to the same.

Certain actigraphy devices used for the limb movements can be of great importance for initial assessment and also for the provisional diagnosis [10].

WATCH PAT instrument.is another example of the combination device where actigraphy has been instrumental in the diagnosis of the Sleep disorders [17].

Finally it can be concluded that as a device Actigraphy has its own importance being sensitive and accurate, however lacks the specificity. Overall, when combined with other instruments like PSG, Sleep diaries and other tools actigraphy can be really instrumental in both Sleep research and Sleep Medicine.

### Bibliography

1. Bass J and Takahashi JS. "Circadian Integration of Metabolism and Energetics". *Science* 330.6009 (2010): 1349-1354.
2. Zucconi M and Ferri R. "Assessment of sleep disorders and diagnostic procedures". *European Sleep Research Society* (2014): 120-121.
3. Carney CE., et al. "The Consensus Sleep Diary : Standardizing Prospective Sleep Self-Monitoring". *Sleep* 35.2 (2012): 287-302.
4. Ferber R., et al. "ASDA Standards of Practice Portable Recording in the Assessment of Obstructive Sleep Apnea". *Sleep* 17.4 (1994): 378-392.
5. Kushida CA., et al. "Practice Parameters for the Indications for Polysomnography and Related Procedures : An Update for 2005". *Sleep* 28.4 (2005): 499-521.
6. Actigraphy R., et al. "Reliability of Sleep Measures from Four Personal Health Monitoring Devices Compared to Research-Based Actigraphy and Polysomnography". *Sensors (Basel)* 16.5 (2016): E646.
7. Manconi M., et al. "Measuring the error in sleep estimation in normal subjects and in patients with insomnia". *Journal of Sleep Research* 19.3 (2010): 478-486.
8. Baker FC. HHS Public Access 32.7 (2016): 1024-1028.
9. Natale V., et al. "The role of actigraphy in the assessment of primary insomnia : a retrospective study". *Sleep Medicine* 15.1 (2014): 111-115.
10. Sadeh A. "The role and validity of actigraphy in sleep medicine : An update". *Sleep Medicine Reviews* 15.4 (2011): 259-267.
11. Meltzer LJ., et al. "Use of actigraphy for assessment in pediatric sleep research". *Sleep Medicine Reviews* 16.5 (2012): 463-475.
12. Spriggs BWH. "Essentials of Polysomnography : A Training Guide and Reference for Sleep Technicians". 2008-2009 (2008).
13. Van Der Kloet D., et al. "Dissociative symptoms and sleep parameters - An all-night polysomnography study in patients with insomnia". *Comprehensive Psychiatry* 54.6 (2013): 658-664.
14. Gjevre JA., et al. "Comparison of polysomnographic and portable home monitoring assessments of obstructive sleep apnea in Saskatchewan women". *Canadian Respiratory Journal* 18.5 (2011): 271-274.
15. Horne RSC and Biggs SN. "Actigraphy and Sleep/Wake Diaries". *The Oxford Handbook of Infant, Child, and Adolescent Sleep and Behavior* (2013): 1-25.
16. Marino M., et al. "Measuring Sleep : Accuracy, Sensitivity, and Specificity of Wrist Actigraphy Compared to Polysomnography". *Sleep* 36.11 (2013): 1747-1755.
17. Penzel T., et al. "Peripheral arterial tonometry, oximetry and actigraphy for ambulatory recording of sleep apnea". *Physiological Measurement* 25.4 (2004): 1025-1036.

**Volume 10 Issue 4 April 2018**

**©All rights reserved by Aman Gupta.**