Role of Actigraphy in the Diagnosis of Sleep Disorders

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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 hypersomnolence,
4. Circadian rhythm sleep-wake disorders,
5. Parasomnias and

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].

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
- Parosomnias
- 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.

<table>
<thead>
<tr>
<th></th>
<th>Actigraphy</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;Sleep&quot;</td>
<td>&quot;Wake&quot;</td>
<td>Accuracy = 0.848</td>
</tr>
<tr>
<td>PSG Sleep</td>
<td>186,689</td>
<td>8,794</td>
<td>195,683</td>
</tr>
<tr>
<td>Wake</td>
<td>26,572</td>
<td>10,594</td>
<td>37,166</td>
</tr>
<tr>
<td></td>
<td>213,461</td>
<td>19,388</td>
<td>232,849</td>
</tr>
<tr>
<td>Modified Timing</td>
<td>Temporally aligned PSG and actigraphy files used for all analyses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actigraphy</td>
<td>&quot;Sleep&quot;</td>
<td>&quot;Wake&quot;</td>
<td>Accuracy = 0.863</td>
</tr>
<tr>
<td>PSG Sleep</td>
<td>188,746</td>
<td>6,937</td>
<td>195,683</td>
</tr>
<tr>
<td>Wake</td>
<td>24,920</td>
<td>12,246</td>
<td>37,166</td>
</tr>
<tr>
<td></td>
<td>213,666</td>
<td>19,183</td>
<td>232,849</td>
</tr>
</tbody>
</table>

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

Role of Actigraphy in the Diagnosis of Sleep Disorders

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.

<table>
<thead>
<tr>
<th>Control group</th>
<th>Insomnia group</th>
<th>F</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed timea</td>
<td>24.11 ± 1.19</td>
<td>23.50 ± 1.12</td>
<td>1.62</td>
</tr>
<tr>
<td>Get up time</td>
<td>07:53 ± 1.16</td>
<td>08:15 ± 1.25</td>
<td>30.01</td>
</tr>
<tr>
<td>TIB</td>
<td>462.91 ± 48.98</td>
<td>505.54 ± 64.07</td>
<td>93.73</td>
</tr>
<tr>
<td>SOL</td>
<td>9.27 ± 7.48</td>
<td>16.05 ± 14.71</td>
<td>33.57</td>
</tr>
<tr>
<td>MA</td>
<td>16.97 ± 6.78</td>
<td>27.30 ± 17.69</td>
<td>45.10</td>
</tr>
<tr>
<td>FI</td>
<td>28.98 ± 8.97</td>
<td>37.33 ± 16.88</td>
<td>37.49</td>
</tr>
<tr>
<td>IS</td>
<td>.53 ± .12</td>
<td>.51 ± .13</td>
<td>13.06</td>
</tr>
<tr>
<td>IV</td>
<td>.85 ± .21</td>
<td>.81 ± .24</td>
<td>.29</td>
</tr>
<tr>
<td>Low蝾螈TSTb</td>
<td>413.84 ± 45.59</td>
<td>425.49 ± 69.72</td>
<td>14.49</td>
</tr>
<tr>
<td>Low蝾螈NWAK</td>
<td>23.52 ± 11.20</td>
<td>26.56 ± 9.74</td>
<td>23.13</td>
</tr>
<tr>
<td>Low蝾螈WASO</td>
<td>35.79 ± 14.21</td>
<td>57.72 ± 32.08</td>
<td>115.04</td>
</tr>
<tr>
<td>Low蝾螈TWAK</td>
<td>3.88 ± 3.24</td>
<td>6.28 ± 6.67</td>
<td>14.08</td>
</tr>
<tr>
<td>Low蝾螈SE</td>
<td>89.46 ± 3.75</td>
<td>84.18 ± 8.63</td>
<td>72.84</td>
</tr>
<tr>
<td>Medium蝾螈TST</td>
<td>389.86 ± 48.82</td>
<td>396.24 ± 70.93</td>
<td>6.03</td>
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<tr>
<td>Medium蝾螈NWAK</td>
<td>28.91 ± 10.51</td>
<td>31.56 ± 8.87</td>
<td>20.58</td>
</tr>
<tr>
<td>Medium蝾螈WASO</td>
<td>58.62 ± 20.88</td>
<td>87.12 ± 39.77</td>
<td>115.08</td>
</tr>
<tr>
<td>Medium蝾螈TWAK</td>
<td>3.86 ± 3.23</td>
<td>6.12 ± 6.11</td>
<td>13.44</td>
</tr>
<tr>
<td>Medium蝾螈SE</td>
<td>84.57 ± 4.88</td>
<td>78.35 ± 10.01</td>
<td>71.55</td>
</tr>
<tr>
<td>High蝾螈TST</td>
<td>363.73 ± 48.70</td>
<td>364.68 ± 71.53</td>
<td>2.27</td>
</tr>
<tr>
<td>High蝾螈NWAK</td>
<td>30.45 ± 9.54</td>
<td>32.40 ± 7.97</td>
<td>15.01</td>
</tr>
<tr>
<td>High蝾螈WASO</td>
<td>84.88 ± 26.48</td>
<td>118.75 ± 45.92</td>
<td>115.79</td>
</tr>
<tr>
<td>High蝾螈TWAK</td>
<td>3.99 ± 4.16</td>
<td>6.06 ± 6.09</td>
<td>8.24</td>
</tr>
<tr>
<td>High蝾螈SE</td>
<td>78.91 ± 5.76</td>
<td>72.12 ± 10.99</td>
<td>68.76</td>
</tr>
<tr>
<td>Auto蝾螈TST</td>
<td>414.68 ± 53.10</td>
<td>433.34 ± 66.85</td>
<td>24.84</td>
</tr>
<tr>
<td>Auto蝾螈NWAK</td>
<td>21.94 ± 9.06</td>
<td>24.25 ± 8.14</td>
<td>19.94</td>
</tr>
<tr>
<td>Auto蝾螈WASO</td>
<td>32.62 ± 12.09</td>
<td>50.04 ± 25.08</td>
<td>101.74</td>
</tr>
<tr>
<td>Auto蝾螈TWAK</td>
<td>3.87 ± 3.24</td>
<td>6.09 ± 6.10</td>
<td>12.63</td>
</tr>
<tr>
<td>Auto蝾螈SE</td>
<td>90.13 ± 3.14</td>
<td>85.61 ± 7.09</td>
<td>69.84</td>
</tr>
</tbody>
</table>

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.

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 assessori 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

Discussion and Conclusion

Actigraphy has become one of the important diagnostic tools in the field of sleep medicine and research. However, there are both pros and cons of the device being more objective, especially as it is a movement-based tracking device, which can misinterpret wakefulness as being asleep.

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

Though the actigraphy is used in pediatric and infant populations with some success [11], however, overall, the 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 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 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.

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].

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Bibliography


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