**Children Home apnea sleep test (HAST) with video on-line technician attending - a comparison to In-lab full Polysomnography**

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**Abstract:**

**Purpose**: The main study aim was to compare the validity of children sleep apnea data obtained from standard polysomnography (PSG) to home sleep apnea test (HAST) accompanied by an on-line video attending trained technician

**Methods**: 100 children, 54 boys and 46 girls at the ages 3-11 (average age 5.2, std. 1.2) assigned randomly either to in-lab full polysomnography or to home apnea sleep test (HAST). All children were referred to a sleep study in order to rule out sleep apnea

**Results**: We didn't find in t-test comparison any significant difference between the in-lab PSG and HAST with on-line attendance for AHI, ODI, baseline O2, minimum O2 parameters except a significant difference found for time in bed (TIB) and total sleep time (TST) that was significantly longer in the HAST.

**Conclusion**: On-line HAST can provide a safe, convenient and a reliable way to perform sleep study in young children for diagnosis of OSA condition their familiar home environment.

**Key words**: Child, Polysomnography, HAST, OSA, On-line.

**Introduction**

 OSA in children has been recognized as a childhood health disorder with estimated prevalence ranging from 1% to 5% [1-2]. The clinical manifestation usually includes snoring, disrupted sleep, restlessness, sweating and salivation during sleep, excessive daytime sleepiness or hyperactivity and irritation [3-4]. Obstructive sleep apnea (OSA) in children is characterized by irregular partial or complete obstruction of the upper airways during sleep, with the disruption of normal ventilation and sleep patterns caused usually by hypertrophy of the adenoids and tonsils. Other risk factors include obesity, neuromuscular disease, down syndrome and micrognathia [3,5]. Continuous quality sleep is essential for growth, development and good health and well-being. Therefore, left untreated it can lead to adverse health, developmental and behavioral results [5-7]. Considering the high prevalence of OSA and its consequences, early and accurate diagnosis as well as easy accessibility are highly important.

 Full night in- laboratory technician attended polysomnography (PSG) is considered the gold standard for diagnosis OSA in children [2,8]. This sleep study provides an objective measure of: sleep quality, sleep architecture, respiratory parameters and index of the breathing disturbance in sleep. However, in - lab PSG test has some limitations and disadvantages. In lab PSG doesn’t simulate the child’s sleep in his home familiar environment: room, bed and parents. Thus, placement of multiple sensors and electrodes by a foreign technician in a foreign room and bed can be challenging in young children and many times impair cooperation due to mental stress. In addition, some children will experience difficulty to fall asleep or to maintain quality sleep in the lab during the study [9].

 The coronavirus (COVID-19) pandemic has caused pause of nonurgent health care services in order to decrease the risk of infection and limit the spread of the virus, especially in hospital environments. This led to nearly complete closure of sleep laboratories and clinics during lockdown around the world. These days, conducting lab- based sleep studies include not just comfort but also safety issues. As a result, Home Sleep Apnea Test (HSAT) in children is raising interest now more than ever.

In contrast to adult, where home sleep test for diagnosis OSA is the common practice, the clinical use of HSAT in children is not well established for diagnosing OSA in children. There is insufficient number of studies comparing the effectiveness of HAST to PSG among children. The use of HAST has the potential to improve a child’s sleep quality as he sleeps in his own bed without the presence of foreign persons, reflecting a typical night and to improve Covid 19 safety issues. In addition, HSAT can increase accessibility of sleep studies for children

The American Academy of Sleep Medicine (AASM) Position Paper summarized 4 published articles focusing on the technical feasibility of HSAT in children. Their conclusion suggests that the likelihood of success dependent on the person who place the sensors and is reduced when the sensors were placed by caregivers instead of trained professionals [8].

 In our study we compared HSAT with on-line video attending trained technician to a standard PSG in children. We hypothesized that HAST with attending on-line technician can provide valid and reliable way for diagnosis sleep apnea in children.

**Methods**

 **Participants**: 100 children, 54 boys and 46 girls at the ages 3-11 (average age 5.2, std. 1.2) assigned randomly either to in-lab full polysomnography or to home apnea sleep test (HAST). All children were referred to a sleep study in order to rule out sleep apnea

 **Polysomnography**: For in-lab full polysomnography we used Standard in-lab Somnoscreen-PSG type sleeping test device (Somnomedics, Germany). Sleep channels included: electroencephalography (EEG), electro-oculography (EOG), leg and chin electromyography (EMG), nasal flow, chest and diaphragm breathing, snoring, electrocardiography (EKG), heart rate, blood oxygen saturation, body position and video. For the home sleep apnea test (HAST) we used a Somnotouch home sleep testing system (Somnomedics, Germany). Sleep channels included: nasal flow, chest and diaphragm breathing, snoring, heart rate, blood oxygen saturation, activity, body position and On-line video recording using Xiaomi 360 web-camera and portable wi-fi card.

**Procedure**: In-lab PSG: The sleep testing room was a standard test room at the Sleep Medicine Research Center at Assuta Medical Center. The child and his parents were invited to the sleep center at 20:00. A skilled and trained technician interviewed the parents about the medical history of the child and then connect the child to the full PSG system in the sleep lab. The technician was monitoring the whole night sleep study from the control center in the sleep lab. The next morning, the parents fill a satisfaction questionnaire. Sleep data analysis was performed by a skilled and trained sleep technicians in accordance with the AASM guidelines (AASM, 2007). We calculated continuity and architecture sleep parameters in addition to breathing and oximetry parameter such as: number of Apnea and hypopnea, apnea hypopnea index (AHI), base-line and minimum saturation, the number of desaturation and the percentage of time below 90% saturation and the percentage of snoring time.

HAST: The parents came without the child to the sleep center in Assuta Medical Center at the evening of the sleep study to meet professional trained sleep technician He reviewed them about the child medical history and guided them and practice with them how to set the system on the child at night. They received the home sleep test system including the digital video camera. This meeting lasts 20-30 minutes. When the parent gets back home, they set up the sleep apnea system with an on-line assistance of the technician, that instructs the parents how to put the system and the sensors on the child using the cellphone and watching the child via the on-line video. After the setup completed, the technician monitored whole night home sleep study using the web camera. If there was a problem with any sensor the technician calls the parents by phone and instruct them how to re-attach the sensors or the system on the child. Next morning when the child wakes up the parents took-off the sleep system and returned it to the sleep center for analysis. The parents asked to fill a satisfaction questionnaire for the home sleep study similar to the satisfaction questionnaire filled by parents after PSG. A legate sleep study, home or in-lab' was if there was at least 70% valid information from the sleep study. For the HAST studies a professional scoring technician score: total sleep time (TST), time in bed (TIB), and sleep efficiency (SE), number of Apnea and hypopnea, apnea hypopnea index (AHI), baseline and minimum saturation, the number of desaturation and the percentage of time below 90% saturation and the percentage of snoring time.

**Results**

We found no differences in the demographic (gender and age) and success ratio and OSA diagnosis proportion in the sleep studies between the in-lab PSG and HAST [ Table 1 ].

**Table 1:** Demographic, succeed ratio and OSA diagnosis percentage for in-lab PSG and HAST.

|  |  |  |  |
| --- | --- | --- | --- |
| p. value | HAST | In-lab PSG |  |
| N.S. | 27/23 | 23/27  | Gender (M/F) |
| N.S | 5.7 (1.4) | 5.4 (1.2) | Age (std.) |
| N.S | 46/50 (92%) | 47/50 (94%) | Succeed ratio  |
| N.S. | 31% | 28% | OSA diagnosis |

Table 2 presents the Apnea Hypopnea Index (AHI), Oximetry disorder index (ODI), Baseline blood saturation (Baseline O2), minimum blood saturation (minimum O2), percentage time of blood saturation below 90% (TIB90%), Time in bed in minutes (TIB), Total sleep time (TST). We didn't find in t-test comparison significant difference between the in-lab PSG and HAST for all the above parameters except a significant difference found for time in bed (TIB) and total sleep time (TST) that was significantly longer in the HAST.

**Table 2**: Breathing disorder index (AHI), oximetry parameters and time in bed and total sleep time duration.

|  |  |  |  |
| --- | --- | --- | --- |
| p. value | HAST Average (std.) | In-lab PSGAverage (std.) |  |
| N.S. | 2.5 (3.51) | 2.7 (2.94) | **AHI**  |
| N.S | 2.4 (2.92) | 2.7 (3.50) | **ODI** |
| N.S | 96.9 (4.60) | 96.7 (4.53) | **Baseline O2** |
| N.S. | 90.1 (3.17) | 90.5 (2.68) | **Minimum O2** |
| N.S. | 0.04 (0.07) | 0.03 (0.07) | **TIB90%** |
| P<0.05 | 453.2 (48.46) | 400.8 (51.74) | **TIB (min)** |
| P<0.05 | 416.9 (44.59) | 364.7 (47.10) | **TST (min)** |

Figure legend: Apnea Hypopnea Index (AHI), Oximetry disorder index (ODI), Baseline blood saturation (Baseline O2), minimum blood saturation (minimum O2), percentage time of blood saturation below 90% (TIB90), Time in bed in minutes (TIB), Total sleep time (TST).

Our results revealed that the parents were very satisfied with HAST. In general, the parents graded high scores for the HAST. They report that the night reflected a regular night of the child, the setup was friendly and easy and the technician was available and pleasant [ Table 3 ].

Table 3: Satisfaction results from the parents' questionnaire of the HAST

|  |  |
| --- | --- |
| Does the sleep study night reflect a regular night of the child? | 4.4/5 |
| How satisfied are you from the technician service and support? | **4.9/5** |
| Did the child fully co-operate with the HAST?  | **4.6/5** |
| From your point of view, does the HAST is complicated to preform?  | **1.7/5** |
| How satisfied are you from the HAST?  | **4.6/5** |

Figure legend: Satisfaction questionnaire of the parents from the HAST. 1-very low, 2-low, 3-nutural, 4-high, 5-very high.

**Discussion**

As described above in details, we found no differences between in-lab full PSG and HAST in all breathing and oximetry parameters for diagnosis of sleep breathing disorder (SDB). It is important to note that the majority of children are referred to sleep laboratories in order to rule out sleep related breathing disorders [10]. Therefore, a sleep study for children in this medical question should be focused on children breathing and oximetry channels and video (picture and sound) in order to evaluate their sleep related breathing disorders. Additional support comes from previous studies that found no differences between HAST and in-lab PSG for evaluating OSA in children: Goodwin et.al., reports no differences in PSG performed within 2 months after HAST in the respiratory parameters [11]. Jacob et al., performed both an HAST and PSG within 1 week for diagnosis of OSA in children revealed good correlation between the two types of studies [12]. Alonso-Alvarez and colleagues compared an HAST to simultaneously PSG and no significant differences were observed in total number of apneas or hypopneas between the HAST and the PSG or in-laboratory respiratory polygraphy studies [13]. These reported studies did not have an online information about the sleep study. From our point of view Hast with an on-line supervision and attendance of technician is even more reliable and suitable approach to perform home sleep studies for diagnosis OSA in children.

 The gold standard for the diagnosis of obstructive sleep apnea (OSA) in children is in-laboratory polysomnography (PSG) [2,8]. One major reason for the preferability of in-lab sleep study is the claim for attendant of skilled technician during the setup phase and the control of the sleep study. In our HAST sleep studies we used an On-line technician supervision that was all night attendant using a web video camera in order to monitor the sleep study. We find that the parent's guidance before the sleep study and on-line video supervision of technician during the set-up of the system on the child and online monitoring during the night can replace the claim for physical attendance of technician. Additional support for our position comes from the fact that we did not observe a difference in failure rate of sleep studies between in-lab full PSG and HAST with on-line technician, in our study we did not observed advantage for physical attendance of the technician over the on-line attendance. Our results support that HAST with on-line is a valid and represents the regular sleep time of the child in his natural environment. Longer sleep time of the child in HAST with on-line reveals higher validity of the sleep study.

Although home sleep apnea testing is widely used in adults to diagnose OSA [14], its use in children has been much more limited, reflecting concerns about the validity of this sleep study in this population, especially regarding the ability to measure accurately the duration of sleep time. A major challenge with HAST in children is the ability to determine the sleep time without using EEG, EOG and EMG channels. Actigraphy is suggested a reasonable technique for measuring sleep due to its high accuracy (85-90%) and sensitivity- the ability to correctly identify sleep (90-97%). Marino et al. concluded that actigraphy is a useful and valid means for estimating total sleep time with some limitation in specificity (the ability to correctly identify wake) [15]. Yet, specificity has been higher in studies of nocturnal sleep-in children (54-77%) [16].  In our data, the time in bed (TIB) and the total sleep time (TST) were longer in HAST compared to in-lab PSG due to home schedule that is different from sleep lab time limitations. In our HAST we calculated time in bed (TIB) and total sleep time (TST) using two more channels besides activity - position and video. We believe that the combination of these three channels is more sensitive and specific than activity only. It needs to be evaluated in more studies.

A major question with in-lab full polysomnography is "Does the sleep study in the sleep lab reflects the regular sleep of the child?" from our extensive experience in Assuta Medical Center sleep lab, some children will experience major problem to sleep in an unfamiliar environment and not in their own bed when they assigned to sleep study, and even they succeed to fall asleep in the sleep lab their sleep is not similar to their regular sleep at home. The parents' questionnaire that we collect during our study support our idea that home sleep studies for children should be preform in the natural sleeping environment of the child. We observed from the parents answers high rates for similarities of the HAST night to regular night of the child. Moreover, parents report high co-operation of the child to the sleep study at home. Finally, parents rank with high score for satisfaction from the HAST in general. Taking together these results, we find that HAST with on-line supervision is a good way to preform home sleep study with high satisfaction of the parents and the child.

The corona virus pandemic (covid-19) pushed forward the use and the legitimacy of telemedicine in many areas in medicine. The global lockdown caused full stop of most non-urgent medical services including in-lab PSG, these days, we are looking for new, safe and valid ways to preform sleep studies for diagnosis OSA children. HAST can increase the availability of providing sleep studies to children in the geographic periphery.

 Finally, On-line HAST can provide a safe and reliable way to preform sleep study to rule out OSA in child’s own bed and house taking care by his parents allowing the child to sleep according to his regular and natural sleep. Taking together these advantages of HAST with on-line technician supervision, we believe that this method of preforming sleep study should be the first choice of sleep study for diagnosis OSA in children.

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