Polysomnography Following an Indeterminate HSAT: Low Compliance with AASM Guidelines

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Introduction

Home sleep apnea test (HSAT) provides a low risk, cost-effective, and convenient diagnostic test for obstructive sleep apnea (OSA) in adult patients. Yet, HSATs suffer from lower signal quality and the absence of EEG, EOG, and chin EMG for the accurate assessment of total sleep time (TST).

This can lead to missed respiratory events and introduces the need for the utilization of monitoring time (MT) instead of TST [1] for the calculation of the patients' Apnea-Hypopnea Index (AHI). This may result in the underestimation of the AHI value and ultimately to the negative diagnosis of patients suffering from OSA.

Consequently, in situations where HSAT produce a negative result, the American Academy of Sleep Medicine (AASM) strongly recommends that a follow-up polysomnography (PSG) be performed [2].

In this study we asses whether patients tend to comply with the AASM guidelines, whether receiving a follow-up study influences the final diagnosis of the patients, and whether utilizing an Artificial Intelligence (AI) based model to score TST can increase the sensitivity of HSATs and help with improving the diagnosis of OSA patients in a home test environment.

Methodology

In order to assess the effectiveness of the AASM guidelines, we have conducted an observational study with N=1,829 patients that received a HSAT in 2019 from 6 independent AASM accredited sleep centers across the U.S. Our dataset included patients' age, sex, AHI, and the full night recordings of their HSAT. We also obtain the AHI of patients who received a follow-up PSG test.

Compliance Analysis

First, we analyzed the proportion of patients that complied with the AASM guidelines across two main demographics, sex and age group. We defined the age groups as 19-33, 34-48, 49-64, 65-80 [3]. The general distribution of sex and age in our dataset can be seen in Figure 1.

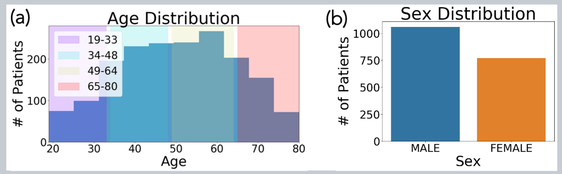

Figure 1. Demographic Distributions.
(a) The distribution of age in the dataset with the different age groups annotated as shaded areas in the figure.
(b) The distribution of sex in the dataset.

We then focused on patients that received a follow-up PSG, considering the original AHI as compared to the follow-up AHI.

Methodology Continued

TST Analysis

We utilized a deep neural network to score Sleep/Wake [4] for all negative HSATs and assessed whether an AI-based approach increases the likelihood of a positive OSA diagnosis. The AI model was trained to output the Sleep/Wake architecture based on full night Photoplethysmogram (PPG) recordings. Then, the trained model was used on all negative HSATs and TST was calculated from each patient's predicted Sleep/Wake architecture. Next, we calculated the patients' AHI utilizing both the AI based TST and MT in the following manner:

$$1.\quad AHI_{MT} = \frac{Number\ of\ Respiratory\ Events}{MT}$$

$$2.\quad AHI_{AI-TST} = 4\frac{Number\ of\ Respiratory\ Events}{TST_{AI}}$$

Finally, we compared between the two in order to observe the effect of utilizing AI based TST on the AHI calculation and OSA severity of the patients.

Results

Compliance Results

Out of all 1,829 patients in our dataset, 68% received a positive OSA diagnosis and 32% received a negative OSA diagnosis. Out of all patients that received an initial negative diagnosis, only 13% complied with the AASM guidelines and underwent a follow-up PSG.

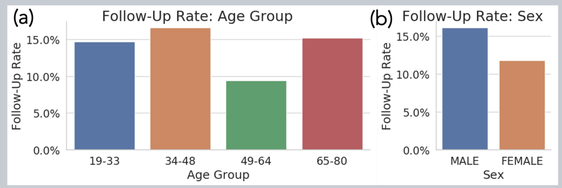

Figure 2. Follow-Up Rate for Each Demographic Group.
(a) Follow-Up rate for each one of the age groups.
(b) Follow-up rate for males and females. For both plots, each bar shows the rate for that category. For example, the follow-up rate for the age group 65-80 is 15% which means that 15% of all patients who received a negative OSA aged 65-80 underwent a follow-up PSG.

Figure 2 displays the percentage of patients that received a follow-up PSG for each one of our demographic groups. From the analysis we observed that younger patients tend to comply more with the AASM guidelines compared to 49-64 age group.

However, after the age of 65, the compliance increases which may be attributed to the Medicare eligibility of patients 65 years or older. Furthermore, it appears that male patients are slightly more likely to reach out for a follow-up PSG when given an initial negative OSA diagnosis from a HSAT.

Results Continued

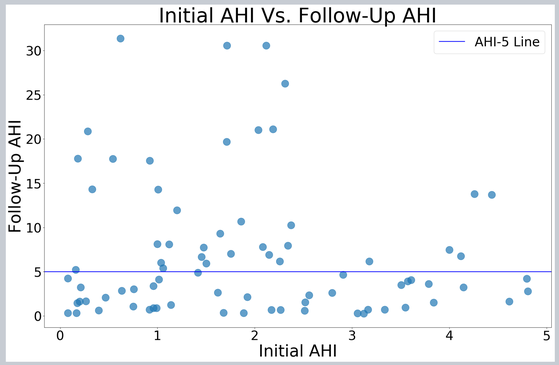

Figure 3. Comparison Between Initial HSAT AHI and Follow-Up PSG AHI.
A scatter plot comparing the initial AHI values and the follow-up AHI values for all patients that received an initial negative HSAT and underwent a follow-up PSG. The follow-up AHI-5 line is annotated in the figure to demonstrate the proportion of the patients that received a positive test from their follow-up PSG.

Figure 3 compares between the AHI from the initial HSAT and the AHI from the follow-up PSG. It can be noticed that receiving a follow-up PSG study has a noticeable effect on the final AHI for some of the patients and changes their diagnosis from no OSA to mild, moderate, and even severe OSA. Out of all these patients, 56% remained with a negative OSA diagnosis, 30% were diagnosed with mild OSA, 10% were diagnosed with moderate OSA, and 4% were diagnosed with severe OSA. This analysis stresses the importance of a follow-up PSG when an initial negative HSAT is received.

TST Results

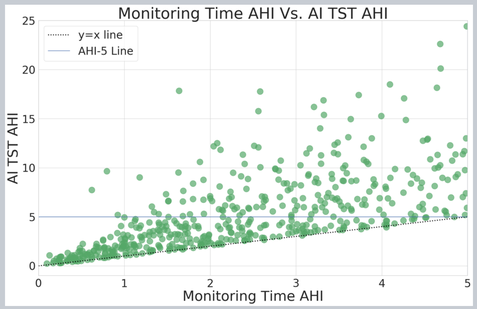

Figure 4. Comparison Between MT Based AHI and AI-TST Based AHI.
A scatter plot comparing between the AHI values calculated utilizing two different sleep metrics, MT and AI-TST. The AHI-5 line is annotated in the figure, as well as the y=x line, to demonstrate the increased likelihood of a positive OSA diagnosis when AI-TST is used instead of MT.

Results Continued

The current standard of practice in various clinics across the U.S. is to utilize MT when calculating the AHI from HSATs. Figure 4 demonstrates the difference between AHI (MT) and AHI (AI-TST) for all patients that received a negative diagnosis from their initial HSAT. It can be noticed that as expected, AHI (AI-TST) is indeed more likely to result in a positive AHI when compared to AHI (MT).

Out of all patients that received a negative OSA diagnosis, 58% of the patients would have still been diagnosed as not having OSA, 38% would have been diagnosed with mild sleep apnea, and 4% would have been diagnosed with moderate sleep apnea if AHI (AI-TST) would have been used instead of AHI (MT).

This illustrates the potential of utilizing AI-based sleep metrics in order to improve the AHI calculation in a home setting where EEG, EOG, and chin EMG are absent from the test and prevents from the accurate assessment of TST.

Conclusion

The overall percentage of patients who comply with the AASM guidelines is relatively low at 13%. Emphasis should be put on patient outreach and education to improve this statistic. Such endeavors may try to target female and middle-aged patients who appear to be slightly less compliant with AASM guidelines.

Simultaneously, more attempts should be made to improve HSAT recordings and analysis in order to increase OSA diagnosis performance and decrease the necessity for a follow-up PSG, as the AASM guideline is often overlooked by patients.

References

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