

# Clinical Effects of White Noise on Improving Sleep Quality: A Literature Review

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## ABSTRACT

White noise is a non-pharmacological way to speed up falling asleep and improve sleep quality which has high operability and simplicity. The prevailing view is that the scientific basis for this approach is "providing a relatively safe and comfortable environment" and "masking ambient noise". This review provides a comprehensive review of the literature on the effects of continuous white noise on sleep quality. Animal studies were excluded, as were studies of the clinical effects of drug interventions on white noise. Sleeping quality included assessments of sleep onset latency, number of sleep interruptions, time to fall back to sleep after interruptions, time spent in deep sleep, and environmental noise. Heterogeneity exists in the loudness range of white noise, measures of sleep quality, adherence to intervention control conditions or interventions, and co-existing experimental interventions. There may be variability in the findings, with extreme cases where constant noise improves or interferes with sleep. There exists strong evidence which is age-specific and occasion-specific in existing studies that white noise improves sleep quality.

**Keywords:** *White noise, Sleep quality, Clinical effect, EEG*

## 1. INTRODUCTION

### 1.1 Background information & significance

Sleep is of great significance to people's mental and physical health. The quality of sleep is closely related to our human growth, development and longevity. [1] With the acceleration of people's pace of life and the increase of work pressure, people's mental burden is also increasing, resulting in the decline of sleep quality, and the accompanying mental diseases are also on the rise. [2] The side effects of taking sleeping pills which is the traditional way to intervene sleep mainly affect central inhibition and digestive symptoms. [3] What's more, it is easy to cause drug dependence. It is significant and necessary to find some new non-pharmacological interventions. White noise interventions, which are highly discussed and practical, are therefore a reliable alternative to drugs. People define the sound with uniform loudness distribution in the auditory range of human ears (20hz-20000hz) as "white noise". [4] When we use white noise for medical purposes, the loudness of the sound usually does not exceed 10000 hertz. [5] At the same time, the upper limit of white noise loudness selected for this study is about 60 decibels, which is not

in the range of noise loudness that affects hearing. Research on white noise has been going on for the last century, and there is growing evidence that it can positively affect sleep, but white noise is still not officially used by the medical community.

### 1.2 Scientific support

Existing scientific research offers two explanations for why white noise improves sleep quality. First, although white noise is continuous sound, but the sound is very stable, the tone does not change. Therefore, there is no change in attention or mood for the listener. [6] In a series of experiments, white noise was described by subjects as a natural sound, such as rain dripping on the ground during rain, waves lapping on the shore during high tide, or leaves shaking in the wind in the trees. People call the white noise as "the sound of nature", and it is stable and harmonious, which gives people a sense of spiritual security. People are more likely to calm down and fall asleep when they are in a safe and comfortable environment, which is why white noise can help people fall asleep faster. Second, white noise can effectively help reduce the impact of environmental noise on people's sleep. The World Health Organization estimates that "nearly 25 percent of the population suffers from

sleep disturbances due to ambient noise". Experiments show that when two different loudness sounds exist, the loudness of the loud sound can obscure the loudness of the small sound to a certain extent. This allows people to sleep safely and comfortably at night, even in the presence of ambient noise. [7] For people with high sensitivity to ambient noise, the improvement in sleep quality was significant.

## **2.MATERIAL SELECTION AND METHOD**

This review reviews the published clinical trials on the effects of white noise on sleep quality in each country over the last 20 years. The author fully understands the experimental process, experimenters' conditions, experimental results and influencing factors of each experiment. More than 90 percent of the experiments were conducted under the guidance of professional physicians, with samples ranging from 30 to 200 individuals.

A certain number of patients with depressive disorder were randomly divided into two groups with half of the certain number of cases in each group. The control group received routine sleep promoting nursing which is no drug related, and the experimental group received white noise intervention on the basis of the control group. [8] In some of the experiments, white noise was played two hours after the experimenters were in bed; while in other experiments that are in the hospitals, the white noise was stopped after the experimenters fell into deep sleep based on observations of brain waves. [9] The whole experiment would last for one month or more. The experiments in a small number of selected papers did not set a control group, but the data of various sleep factors in different periods in the experimental group were clearly analyzed, and the experimental environment was relatively stable.

## **3.MEASUREMENT**

There are two main ways to measure sleep quality: Sleep Questionnaire score and EEG observation of sleep state. In fact, they are often used in combination to assess sleep status and quality. Among the selected studies, the most frequently used sleep questionnaires were Pittsburgh sleep quality index (PSQI) [10] and Richards – Campbell sleep questionnaire (RCSQ). [11]

These two sleep questionnaires have clear scientific theoretical support and high international utilization and recognition. It is relatively scientific and effective to use them to measure sleep quality. RCSQ is filled in daily, so it has real-time and accuracy. PSQI aims at the evaluation of long-term sleep quality. The questionnaire cycle is basically about one month, so some accidental errors can be avoided. [12]

PSQI includes the evaluation of sleep time, sleep

initiation latency, sleep interruption times, and many other related factors. RCSQ and PSQI have some similarities in sleep quality factors in the questionnaire, but RCSQ pays extra attention to sleep depth and difficulty in falling asleep again. [11] Due to the relevance to the subject of white noise, an assessment of ambient noise at night will be added when using the questionnaires.

Another measure using EEG monitoring requires specific experimental conditions. Electroencephalogram (EEG) is a method of recording brain activity using electrophysiological indicators, resulting from the summations of postsynaptic potentials generated simultaneously by a large number of neurons during brain activity. It records the electrical wave changes of brain activity and is the overall reflection of the electrical physiological activity of brain nerve cells on the surface of the cerebral cortex or scalp. [13] Brain waves are spontaneous, rhythmic neural electrical activity that varies in frequency from 1 to 30 times per second and can be divided into four bands:  $\delta$  (1-3Hz),  $\theta$  (4-7Hz),  $\alpha$  (8-13Hz), and  $\beta$  (14-30Hz). During sleep, there are other normal brainwaves with special waveforms, such as hump wave,  $\sigma$  wave,  $\lambda$  wave,  $\kappa$ - complex wave,  $\mu$  wave, etc. [14] Human's sleep follows sleep architecture because sleep has a biological rhythm. The International Society of Sleep Medicine classifies sleep into five stages: sleep, light sleep, deep sleep, and rapid eye movement. People go through cycles in about 90 to 100 minutes. [15] The body state and the characteristics of brainwave are different in different sleep stages, and the brainwave produced in each sleep stage is different. [16] Therefore, it is very scientific and feasible to observe sleep state by brain wave.

## **4.RESULTS**

### ***4.1 Selection and statistical analysis***

For the articles be selected in this review, all data were input into spss statistical software for analysis and processing. The measurement data were expressed in ( $x \pm s$ ). T-test was used for comparison between groups. ( $P < 0.05$  was statistically significant.) [8]

### ***4.2 Synthesis of results***

More than 90% of the experimental results were described in accordance with the following description. After the treatment, the score of sleep scale (RCSQ or PSQI) in the experimental group was better than that in the control group. There were significant differences in sleep depth, difficulty in falling asleep, times of awakening, difficulty in falling asleep again, overall sleep quality and night environmental noise between the two groups ( $P < 0.05$ ). EEG measurements also showed that people took less time to fall asleep and spent more

time in deep sleep after the white noise intervention, suggesting an overall improvement in sleep quality. [17-24]

### **4.3 Sleep onset latency**

From the data summary of each paper, the amount of time it took to fall asleep was reduced by a third or more than before the white noise intervention. Notably, in some of the papers, those experimenters who exposed to white noise reported feeling calmer just before falling asleep. [17-24]

### **4.4 Sleep quality**

When the results of the various papers were combined, it was found that white noise had a significant positive effect on sleep quality, whether from sleep questionnaire scores, or precise scientific observation of EEG. In addition, the vast majority of experimenters reported that white noise improved their sleep. [25]

### **4.5 Ambient noise**

The ambient noise index is not a measure of the level of sound heard, but the effects of ambient noise on sleep, such as being kept awake or having light sleep due to a noisy environment is a negative effect. Among the collected papers, the environmental noise index changes the most and the most rapidly in each experiment. With the intervention of white noise, the negative impact of environmental noise on people's sleep turned into a positive one. This also proves the masking effect of white noise on other noises in the environment proposed in scientific theories, as well as the comfort and security effect of white noise itself. [17]

## **5.CONCLUSIONS**

### **5.1 Strengths and limitations**

It is clear from this review that a growing number of scientific and formal experiments have demonstrated that white noise does have a positive effect on sleep quality in humans. [26-30] Age and use of the occasion as a different case of the division of standards. So far, white noise has been best studied in infants and toddlers (ages 6 months to 5 years), where it has been shown to help them fall asleep and reduce the number of times they wake up in the night. [20] And over time, there were no side effects worth mentioning. Currently, the most well-studied setting is in the hospital room. Whether for patients admitted to the ICU for physical illness or admitted for observation for mental illness, white noise significantly improved their sleep quality. [9]

The study was limited by age coverage and a lack of long-term monitoring of side effects. Except for those

involving infants and young children, most of the experiments were not clearly divided by age, which resulted in a lack of research comprehensiveness. Especially for the adolescent group, middle-aged and elderly groups, these experimental groups that are relatively blank in the existing experiments need further experiments and studies. Some refuted views suggest that long-term use of white noise can lead to dependence and possibly damage hearing. Unfortunately, there are no official studies proving these side effects. But it's also hard to gather evidence that white noise has no side effects at all. Notably, white noise has been shown to have no significant side effects in infants and young children. It remains a matter of reservation whether white noise will be widely used. Follow-up studies of this study will need longer cycles and more sophisticated observations to determine the safety of using white noise to improve sleep quality. In any case, the idea that white noise has a positive effect on improving sleep quality has been basically proven.

### **5.2 Application prospect**

In contemporary society, more and more people have sleep problems. In particular, people living in cities can hardly avoid sleep disturbances caused by environmental noise. At the same time, more and more people begin to pay attention to their health. Many products are created in order to help people have a better living environment. Most of the common existing health products have monitoring capabilities, such as health watches. Adding the ability to play white noise into such smart products and stopping it when it detects a person falling asleep could improve sleep quality. The traditional way to deal with sleep problems is to take sleeping drugs, which can cause negative effects such as central inhibition, digestive symptoms and drug dependence. White noise is easy to obtain, easy to use, very effective and it can be combined with emerging technologies. Therefore, white noise has good future prospects.

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