ORIGINAL RESEARCH

# Electromagnetic Field Exposure and Sleep: An Investigation into the Effects and Potential Interventions to Improve Sleep Quality

Rekha Dwivedi,[1] Amar Pratap,[2] Renjith Appukuttan,[3] Sunita Rana,[4] Sonam Panwar,[5] Sachin Kumar,[6] Pranav Poddar,[7] Manjari Tripathi[8]

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## Abstract

The extensive use of telecommunication devices and electronic gadgets has increased tremendously in the last decade, so it becomes necessary to look at the possible impacts on various aspects of health. Overnight polysomnography was done on 22 healthy subjects to assess their sleep pattern and the related parameters. This was an exploratory pilot study, reporting the sleep efficiency of the participants surrounded by wireless devices and the efficacy of Enviroglobe in improving the same. The results indicated statistically significant changes in sleep stage N3 (deep sleep) and arousal index REM with the usage of Enviroglobe. While sleep efficiency and apnea index also showed a trend toward significance with the use of the Enviroglobe, no significant changes were observed in NREM, N1, N2, and snoring and apnea events. Considering the benefits of good sleep on an individual's physical and mental health, and the positive results of this pilot study, further study in a larger population is encouraged.

**Keywords:** Deep sleep, Electromagnetic fields, Envirochip, Enviroglobe, Environics, Sleep efficiency.

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## Introduction

Telecommunication devices such as cellular phones, laptops, Wi-Fi routers, televisions, and even microwaves, all contribute to ambient invisible electromagnetic fields (EMFs). We are surrounded by these electromagnetic emissions, even while sleeping, and this may have a deleterious effect on the health of the users.[1]

There is evidence from across the globe that electromagnetic emissions may increase the stress levels in the human body and may cause depression[2–4] and disturbance in the brain waves,[5] increase the risk of heart diseases[6] in adults, and disturbance in the sleep quality,[7] even affecting the unborn child[8,9] and children.[10–12] In fact, the evidence from brain imaging also indicates that EMF from devices like mobile phones can alter the regional cerebral blood flow, sleep, and waking EEG of the participants.[13–16]

Regulatory authorities worldwide have suggested precautions and have set stringent criteria for managing EMF exposures from emerging wireless technologies as they may pose a serious threat to public health consequences.[17]

The Enviroglobe invented by Syenergy Environics, Gurugram, India uses technology involving an array of crystals, that may alter the nature of digital smog waveforms from constant to random, making them less harmful to humans. The current study aims to examine the impact of wireless technology/devices on sleep quality and the efficacy of Enviroglobe in improving the same.

## Materials and Methods

The interventional study was performed on 22 healthy subjects having age between 18 and 60 years. The study was conducted at the All-India Institute of Medical Sciences, New Delhi, India, after approval by its institutional ethics committee, vide letter no (IEC-228/09.04.2021, RP-32/2021). The study was registered by the clinical trial registry of India CTRI/2021/06/034482 [Registered on: 30/06/2021].

[1–3,5,6,8]Department of Neurology, All India Institute of Medical Sciences, New Delhi, India

[4]Department of Neurology, Syenergy Environics Ltd, Haryana, India

[7]Department of Research, Syenergy Environics Ltd, Haryana, India

**Corresponding Author:** Sunita Rana, Department of Neurology, Syenergy Environics Ltd, Haryana, India, Phone: +91 124-4614154, e-mail: sunita.rana@environics.co.in

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**Conflict of interest:** None

An informed consent was obtained from all participants. All participants were assured of the confidentiality of their personal information. All the participants were counseled to explain the study rationale and terminologies used in the questionnaire-related stress.

### Inclusion Criteria

- Healthy participants between 18 and 60 years who were willing to participate in the study and were physically fit and had no comorbidities (Fig. 1).
- The participants who were not suffering from any brain related to chronic disease.

### Exclusion Criteria

- People suffering from any sleep disorder or any chronic physical or mental illness, affecting their sleep.
- People with any chronic respiratory problem (including nasal congestion, chest infections, asthma, adenoids, allergic rhinitis,

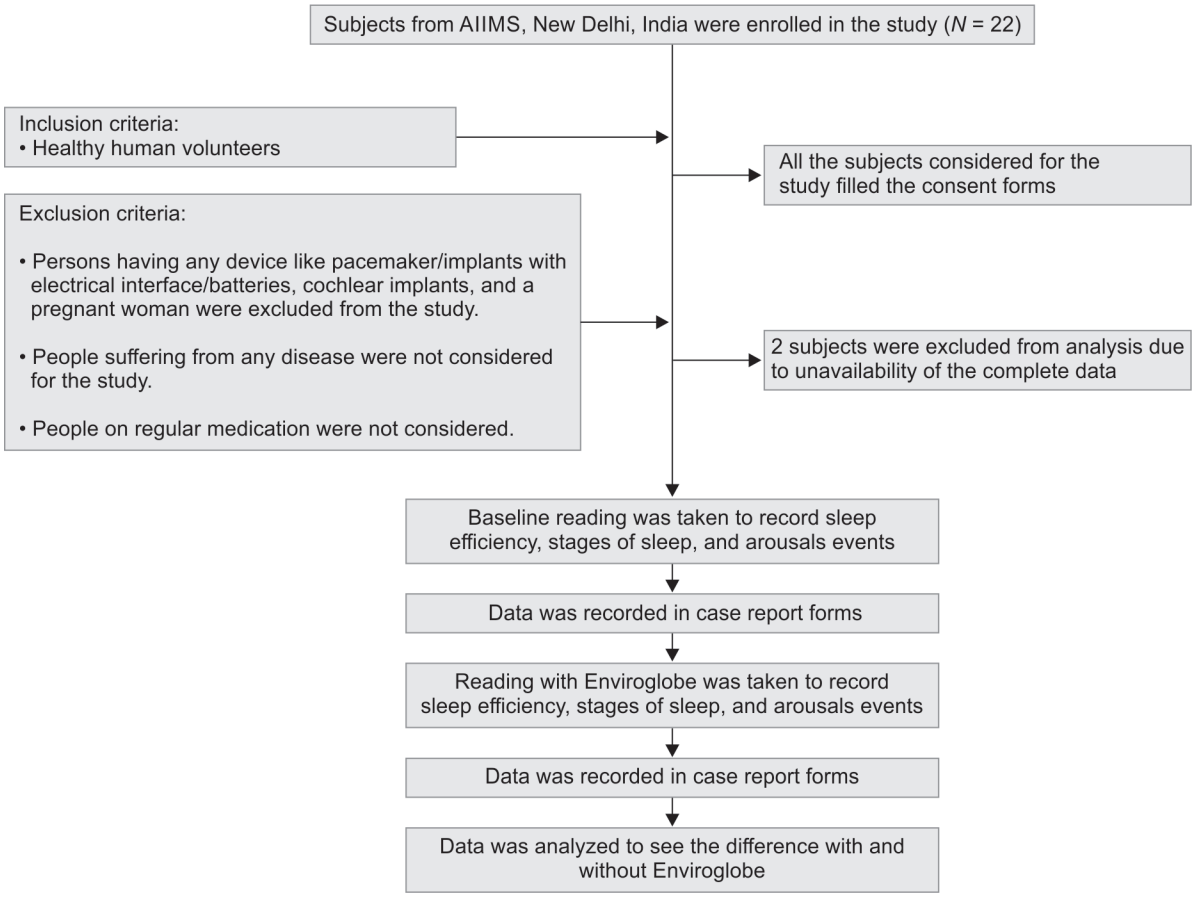


**Fig. 1:** Flowchart of the study

etc.), having any device like pacemaker/implants with electrical interface/batteries, cochlear implants, and pregnant women.
- People on regular medication for metabolic, neurological issue, or any other severe condition.

## Data Collection

Sleep data were recorded using the SOMNOmedics in Lab Polysomnography (SOMNOmedics GmbH, Germany), powered by the patented Domino Sleep Diagnostic software.[18] It records continuous and undisturbed blood pressure during sleep. It has stationary and mobile applications in one device and interfaces for the integration of external systems. The equipment does continuous impedance checks, detection of Cheyne stokes, arousals based on path analysis, MSLT and split night reports, and snore topographic analysis for localization of snoring.

Data were recorded for the sleep efficiency, stages of sleep, REM time, NREM, heart rate variability, arousal events, total sleep time, $SpO_2$, snoring, and apnea electroencephalogram were noted.

We followed the methods of Tripathi et al.[19] Data of the participants were recorded for a total of two nights (22:00–06:00 hour) in the sleep laboratory. Polysomnography (sleep study) was performed for each subject to establish the baseline and then same recording was done in similar controlled conditions with Enviroglobe, in the second session. There was a gap of 10 days between the baseline data recording and recording with the Enviroglobe. Each recording was preceded by a readiness session designed to help participants acclimatize to the laboratory conditions and also to rule out the presence of any sleep or neurological disorders. The subjects were also monitored for confounding factors which could affect results. These included intake of coffee/tea, last night's sleep quality and any kind of work/home-related stress.

## Statistical Analysis

Data were analyzed using STATA 12.0 v (STATA, Corp, Temple, College Station, USA). The dichotomous data were represented as frequency and percentage. Categorical variables were analyzed using the Chi-square test or Fisher's Exact test while a two-tailed paired *t*-test was performed for the pre- and post-data of the Enviroglobe. The non-parametric test (Mann–Whitney) was used to see the effect of Enviroglobe on the sleep patterns of healthy individuals. The alpha level for statistical significance was set at $p < 0.05$.

# Results

A total of 20 subjects were taken for the final analysis as two subjects dropped out due to absenteeism, their demographic details are available in Table 1. The average age of the subjects was 26.75 ± 6.5 years (18–60 years), and all study subjects were male (Table 1). It was seen that the Arousal Index REM, Deep Sleep (Sleep stage n3), and $SpO_2$ of 20 subjects at baseline was 9.7 (range 1.5–59.3), and 17.4 (range 1.9–26.7), and 89.9 ± 5.77. When the subjects were

**Table 1:** Demographic details of the subjects ($N = 20$)

| *Variables* | *Patients with sleep subjects* |
|---|---|
| Total subjects | 20 |
| Age (mean ± SD) | 26.75 ± 6.5 |
| Gender *n* (%) | |
| Male | 20 (100%) |
| Female | 0 (0%) |
| Height (cm) | 162.35 ± 10.9 |
| Weight (kg) | 58.15 ± 8.26 |
| Body mass index (BMI) (mean ± SD) | 22.18 ± 4.40 |

**Table 2:** Comparison between with and without Enviroglobe device of healthy subjects ($N = 20$)

| | *Without an Enviroglobe device (Baseline)* | *With Enviroglobe device* | *p-value* |
|---|---|---|---|
| Sleep efficiency (mean ± SD) | 79.73 ± 9.28 | 85.34 ± 9.23 | 0.078 |
| Total arousal [table median (min–max)] | [184 (58–938)] | [120.5 (40–546)] | 0.225 |
| Arousal event REM | [10 (1–152)] | [7 (1–152)] | 0.330 |
| Arousal index REM | [9.7 (1.5–59.3)] | [5.4 (1.2–59.3)] | 0.001* |
| Arousal event NREM | [81.5 (26–452)] | [54 (15–144)] | 0.24 |
| Arousal index NREM | [14.8 (6–101.6)] | [12.2 (4.2–53.8)] | 0.322 |
| Arousal event sleep | [92 (29–469)] | [56.5 (20–273)] | 0.161 |
| Arousal index sleep | [14.1 (4.6–92.4)] | [9.1 (4.3–56.7)] | 0.173 |
| $SpO_2$ | 89.9 ± 5.77 | 87.2 ± 6.96 | 0.046 |
| HRV | 60.85 ± 7.58 | 59.35 ± 8.65 | 0.57 |
| Snoring | [3.25 (0–73.7)] | [3.45 (0–54.6)] | 0.151 |
| Apnea event | [9 (1–252)] | [5 (1–218)] | 0.13 |
| Apnea index | [1.9 (0.2–48.9)] | [0.9 (0.1–32.8)] | 0.062 |
| Sleep stage REM | 20.13 ± 10.7 | 23.10 ± 8.76 | 0.247 |
| Sleep stage n1 | [6.1 (2.6–20.8)] | [7.25 (1.4–19.5)] | 0.601 |
| Sleep stage n2 | 64.13 ± 63.05 | 50.84 ± 8.31 | 0.55 |
| Sleep stage n3 | [17.4 (1.9–26.7)] | [23.65 (1.6–40.3)] | 0.048* |

*Represented as significant change after the use of the device

using the Enviroglobe, the average score was found to be 5.4 (range 1.2–59.3), and 23.65 (range 1.6–40.3), and 87.2 ± 6.96, respectively (Table 2). This change was found to be statistically significant. No significant changes were observed in NREM, n1, n2, snoring events, and apnea events.

It was observed that the subjects showed statistically significant changes in sleep stage N3 (deep sleep) and arousal Index REM with the usage of Enviroglobe. Sleep efficiency and apnea index also showed a trend toward significance with the use of the Enviroglobe. The $SpO_2$ was found to be significantly reduced with the Enviroglobe. No significant changes were observed in N1, N2, and snoring events.

## Discussion

According to Larik et al., there are many harmful effects of cell phones, laptops, tablets, pc, wireless routers, and Bluetooth devices on the human body because these devices emit different types of EMFs.[20] Miller et al. have recommended investigating and monitoring potential links between EMF associated with wireless technology and cancers, lower sperm count, heart problems, issues related to the nervous system, and sleep.[21]

Numerous epidemiological research on neurological cognitive issues such as headache, tremors, dizziness, memory loss, loss of focus, and sleep disturbance brought about by EMF have found statistically significant findings.[22–25] And an increasing number of people have reported symptoms like insomnia, fatigue, loss of appetite, etc., due to EMF exposure.[26–28]

A cross-sectional study conducted by Abdel-Rassoul et al. concluded that inhabitants living nearby mobile phone base stations are at risk for developing neuropsychiatric problems and some changes in the performance of neurobehavioral functions.[25]

The International Agency for Research on Cancer (IARC) in 2011 classified EMF from mobile phones as possibly carcinogenic to humans (Group 2B), which is the same as tobacco and cigarettes.[29]

The risk to young children in this context may actually be higher as their body systems are still developing. Therefore, the radiation penetration may be more in children as their head diameter and skull thickness is less, with energy-absorbing hot spots, being more pronounced.

Researchers believe that there may be a reason for the association between EMFs and childhood cancers like leukemia[30] and brain tumors. In fact, Rafique et al. additionally reported that one in every four young people is suffering from problematic cell phone use, which is linked to depression, anxiety, and poor sleep quality.[31] It is well documented that the rate of development of Autism,[32] ADHD,[33] and many other problems[34] in young children in the last decade is much higher than it was in any of the previous decades, and researchers have variably correlated it with the use of smart devices.

There's evidence to suggest that prolonged use of laptops, personal computers, and mobile phone poses long-term health implications.[35] Chandra et al. have reported a reduction in the average heart rate variability (HRV) of the participants when they were exposed to the EMF from mobile phones and nearby Wi-Fi devices.[36] In fact, we have also earlier reported increased activity in the alpha, beta, theta, and gamma band of EEG during EMF exposure from mobile phones.[37]

The main goal of this study was to investigate the impact of wireless technology/devices on sleep quality and the efficacy of Enviroglobe in improving the same. The importance of sleep hygiene in wellness cannot be overemphasized. Sleep disturbances or sleep disorders, such as insomnia, hypersomnia, or circadian rhythm sleep–wake disorders, can impair body functions, which can affect a person's health, efficiency, and quality of life negatively. The Australian Sleep Health Foundation National Survey from 2016 concluded that sleep problems and daytime consequences are endemic among adults. A focus on healthy sleep at a policy level as well as increased clinician and public awareness may be warranted.[38]

The average amount of time spent sleeping in the sample was 5.8 hours, which is less than the 7–9 hours suggested by the National Sleep Foundation[39] for adults. However, a significant improvement in Arousal Index REM and Deep Sleep (Sleep stage n3) was noted. Moreover, sleep efficiency improved from 79.73 ± 9.28 to 85.34 ± 9.23, which is a remarkable improvement in sleep quality, and consequently, its healing and reparative effects.

### Limitations of the Study

The small sample size and a racially homogenous population are the obvious limitations of the study. Also, the participants were monitored clinically in a controlled environment, which does not simulate a real-world environment. Moreover, none of the subjects had any concurrent illnesses or reported stress/disorder, which is not representative of the general population.

## Conclusion

Despite the small sample size, there is sufficient evidence to suggest that the use of Enviroglobe may significantly improve deep sleep, arousal events, and sleep efficiency in controlled conditions. Considering the benefits of good sleep on an individual's physical and mental health, and the positive results of this pilot study, further study on a larger population is needed. In fact, real-world evidence, since the study was conducted in a sleep lab, on a larger population with sleep disturbances and other comorbidities may help in a better adaptation of this technology.

### Availability of Data and Materials

All data are included in the manuscript.

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