The Influence of Mobile Technologies on the Quality of Sleep

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ABSTRACT

The extensive usage of mobile phones across all age brackets, including children and teenagers, leads to significant exposure to radiofrequency electromagnetic fields (RF-EMF). This exposure raises concerns about potential adverse effects on sleep. The current study aimed to explore the influence of mobile phone-emitted RF-EMFs on the duration and quality of sleep in a cohort of medical students. Participants alternated between sleeping with and without a mobile phone for two-week intervals, while their sleep patterns were monitored using smartwatches. The study results indicated no statistically significant disparities in sleep quality between sleeping with and without a mobile phone. However, exposure to radiofrequency electromagnetic fields had a notable impact on the minimum and average blood oxygen saturation levels.

Keywords

Mobile Phones; Sleep Quality; Fitness Trackers; Electromagnetic Fields; Radiofrequency

Introduction

Individuals have encountered Electromagnetic fields (EMF) from a variety of sources, including both natural occurrences, such as the Earth's magnetic field, and artificial sources, like electric fields created by the accumulation of electric charges in the atmosphere during storms. Additionally, sunlight carries electromagnetic energy across a range of frequencies, including visible light, infrared, and ultraviolet radiation.

While advancements in technology have undoubtedly enhanced our quality of life, apprehensions regarding potential health effects associated with long-term exposure to EMF are on the rise. Numerous studies have been conducted to investigate the impact of EMF on human health, with some suggesting potential connections to health issues, such as cancer, reproductive problems, and other physiological changes. The International Agency for Research on Cancer (IARC) recently categorized exposure to radiofrequency radiation (RF EMF) as a "possible carcinogen" (Group 2B). Moreover, there is supportive evidence indicating a potential correlation between extremely low-frequency electromagnetic fields and leukemia in children [1].

EMF sources have contributed to the existing natural exposure to electromagnetic radiation, which originates from the sun, the universe, atmospheric discharges, and storms. Of particular interest is

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electromagnetic radiation, including radiofrequency waves, as it has been associated with various short-term effects such as headaches, fatigue, tinnitus, concentration problems, depression, memory loss, irritability, chest pain, immune disorders, and hormonal imbalances. Furthermore, prolonged exposure to electromagnetic fields has been linked to an increased risk of developing cancer [2]. The human body can absorb these waves, particularly from mobile phones, as smartphones are often used in close proximity to our bodies. In recent times, the duration of smartphone usage has escalated, among not only adults but also young individuals, including young children [3].

As a result, there have been increasing public concerns about the potential health effects resulting from RF-EMF exposure. According to several representative surveys of the population conducted in Europe, prevailing health complaints related to RF-EMF exposure are mainly associated with sleep disorders. Several studies propose that exposure to high levels of EMF in close proximity to the bedroom can adversely affect sleep quality. EMF can also disrupt the body's natural biorhythms, leading to difficulties in falling asleep, insomnia, or disruptions in sleep patterns [4].

Sufficient and restorative sleep can significantly decrease the likelihood of respiratory infections and lower the risk of developing serious health issues, including diabetes, heart disease, and other chronic conditions. Sleep deprivation impacts memory, mood, and overall mental well-being [5].

In addition to studies that support the correlation between radiofrequency radiation and sleep quality, there are also numerous studies that fail to confirm this association. For instance, the findings from the study conducted by Tettamanti [6] contradict the hypothesis that long-term use of RF-EMF mobile phones has an impact on sleep quality.

Furthermore, Eeftens et al. [7] conducted a comprehensive study known as the SPUTNIC study, which aimed to examine the potential links between non-ionizing radiation from mobile phones and various aspects of human health, including cognitive abilities, quality of life, and sleep patterns. The research did not find any connections between temporary markers of RF-EMF and cognitive abilities, health-related quality of life, or the duration and quality of sleep.

Material and Methods

In the current study, a total of 36 students from the Faculty of Nursing and Health Professional Studies participated. The participants were divided into four groups, with 9 students each from the fields of nursing, physiotherapy, midwifery, and radiological technology. All of the students were in their first year of study and had not yet commenced clinical practice. Participation in the study was voluntary, and students with chronic sleep problems or those who used sleeping pills were excluded from the study.

Each student was provided with a fitness bracelet (Garmin Vivosmart 4, USA) to wear for a duration of one year. The Garmin device monitored four different sleep stages, which included awake times, Rapid eye movement (REM) sleep, light sleep, and deep sleep. Participants created online accounts and uploaded data related to their sleep patterns, including awake times, REM sleep, light sleep, deep sleep, average oxygen saturation levels (SpO_2), lowest SpO_2, average pulse during sleep, average pulse during the day, and number of steps taken. This data was securely stored in a dedicated cloud space. The Garmin Connect app was utilized by participants to track and analyze their sleep patterns. As part of the study protocol, participants alternated between two-week periods of sleeping near a mobile phone and sleeping without a mobile phone. When sleeping, the mobile phone was positioned at a distance of 1 meter from the student's head.

In line with previous studies conducted by leading scientists [8,9], we also took into

account the potential impact of blue light. All participating students had the sleep mode activated on their mobile phones from 11:00 p.m. until 5:00 a.m. During this mode, the mobile phones did not emit any light or sound when pressed. Additionally, students refrained from using their cell phones for at least 60 minutes before going to bed. Throughout the entire study period, blue light filters were automatically activated on their devices, operating 24 hours a day.

It is important to note that none of the students included in the study were using sleeping pills or melatonin tablets.

Statistical Analysis

The Shapiro–Wilk test was used to determine the normal distribution of the variables. The pair t test was used to compare differences between the different setups. Wilcoxon test was used for comparisons in different setups if the requirements had not been met for normal distribution. IBM SPSS software (version 28.0) was used for statistical analysis, and the significance level was considered at 0.05.

Results

In this study, no significant difference was found in time awake, REM, light sleep, and deep sleep. Deep sleep is very important for physical recovery. Figure 1 displays the duration of deep sleep when participants slept with a mobile phone and when they slept without a mobile phone. The data indicates that there were no significant differences between the two conditions.

However, the initial hypothesis suggested that RF-EMF would have an impact on sleep, this hypothesis was not confirmed in the study. Also, the findings revealed that RF-EMF did have a significant effect on both the minimum and average blood oxygen saturation levels (Figures 2 and 3).

Discussion

There is indeed a considerable body of research focused on investigating the impact of RF-EMF on sleep, with many studies conducted under controlled laboratory conditions utilizing precise evaluation methods, such as polysomnographic recordings [4,5]. Such studies are generally considered to be more accurate compared to the use of smartwatches or fitness bracelets for assessing sleep quality. However, there are advantages to using smartwatches in studies like ours. Laboratory

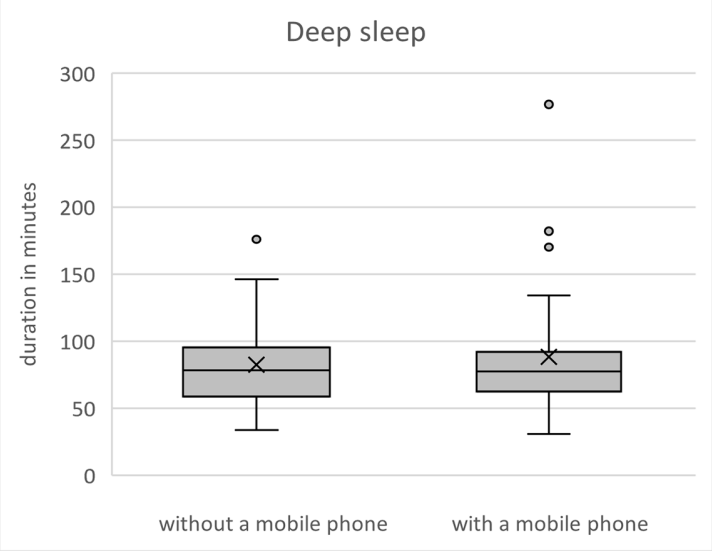

Figure 1: Deep sleep-in minutes

sleep studies can be associated with discomfort for participants who sleep in an unfamiliar environment while being connected to multiple devices. Furthermore, long-term monitoring is often not feasible in a laboratory setting, whereas our study spanned a duration of one year. It is worth noting that the need for sleep in a laboratory environment can significantly affect the quality of sleep.

Regarding the accuracy of fitness bracelets, any systemic errors or inaccuracies inherent in these devices would manifest consistently when measuring sleep quality, regardless of whether the mobile phone was present or absent. By evaluating the differences in measured values, we were able to compensate for these systemic errors to a large extent.

As per the available literature, there is a slight prevalence of studies that do not confirm a correlation between RF-EMF and sleep

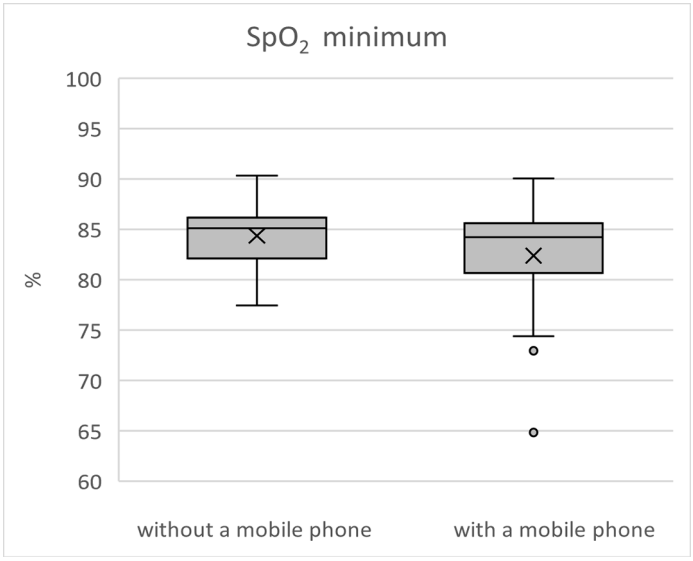

Figure 2: Minimum blood oxygen saturation

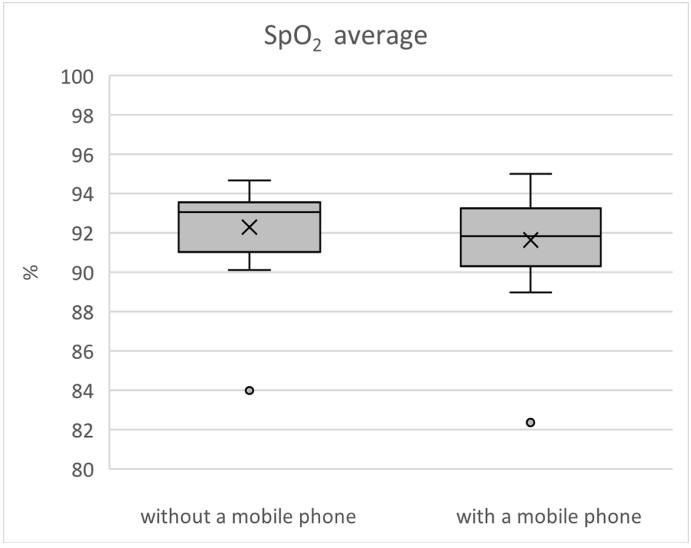

Figure 3: Average blood oxygen saturation

quality [6,7]. It is important to recognize that many websites aggressively promote the notion of significantly negative effects of radiofrequency electromagnetic radiation on sleep, which we believe can be more harmful in terms of sleep disturbance compared to the electromagnetic radiation itself.

Additionally, emerging evidence suggests a potential link between RF-EMF and neurodegenerative diseases, particularly Alzheimer's disease [10]. While the impact of RF-EMF on sleep quality may contribute indirectly to the development of Alzheimer's disease, there is also a possibility of a direct association. It would be desirable to address this issue in further studies. The calcium hypothesis of Alzheimer's disease suggests that an excessive intracellular calcium concentration plays a role in the disease's development, leading to various factors including oxidative stress, inflammation, and excessive signaling. Electromagnetic fields can further amplify these effects.

In summary, while there are studies that support a correlation between RF-EMF and sleep quality, there are also studies that do not confirm this association. The use of smartwatches and fitness bracelets in our study has its advantages, and it is important to consider the wider context and potential effects of RF-EMF on neurodegenerative diseases like Alzheimer's. Further research is needed to gain a better understanding of these complex interactions [10].

Conclusion

During sleep, the deep sleep phase is considered crucial for physical recovery as it facilitates the release of growth hormones and regeneration of organs, muscles, and cells. In our study, we did not observe any statistically significant differences in the durations of wakefulness, REM sleep, light sleep, and deep sleep. However, we did find that RF EMF had a significant impact on minimum and average blood oxygen saturation levels. These findings emphasize the importance of conducting further comprehensive research in this area.

Authors' Contribution

Z. Slezáková conceived the idea. The introduction of the paper was written by J. Baláž. The method implementation was carried out by M. Valachovičová. Results and Analysis were carried out by J. Baláž and S. Wimmerová. The research work was proofread and supervised by Z. Slezáková. All the authors read, modified, and approved the final version of the manuscript.

Ethical Approval

The Research Ethics Committee of the Slovak Medical University in Bratislava approved the project in accordance with the rules and guidelines for human research before the start of research in 2022 (No. 5/2021).

Informed Consent

Participants were informed about the development of the research and those who agreed to participate signed an informed consent form in duplicate, one of which was given to the student.

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Conflict of Interest

None

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