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## The effect of nocturnal mobile phone usage in cognitive physiology

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### Abstract

The media has begun to form an important part of the daily life of young people, the increasing frequency of use of media such as television (TV), computer games, Internet; mobile phone usage threatens healthy sleep. Using the media can change the sleeping time and shorten the sleeping period. The direct exposure to blue light that has been emitted from personal electronic devices can cause damage to the retina thus causing impairment of cognition. It also suppresses the production of melatonin, a hormone that helps to regulate the sleep cycle. Thus the aim of this study is to assess the effects of nocturnal mobile phone usage on cognition and quality of sleep. Methods: The study was carried out using 80 nocturnal mobile phone users in Kakatiya medical college by measuring their cognitive functions and sleep quality. Comparison of cognitive function tests and sleep scores between the groups was done using one-way ANOVA and post-hoc tests. Results: The cognitive function tests scores were decreased significantly in nocturnal mobile phone users and this change was more pronounced with more usage at night. The PSQI scores are significantly increased in nocturnal mobile phone users. Interpretation & Conclusion: From the results we can conclude that nocturnal usage of mobile phones has negative influence on cognitive functions and increased sleep disturbance in subjects with greater mobile phone usage, on comparison with the non mobile phone users at night.

**Keywords:** Cognitive functions, mobile phones, sleep routine, sleep quality index

### Introduction

Sleep is a basic necessity that constitutes almost onethird of the hours in a human's lifetime. It is a state of reversible unconsciousness, where the body and mind are renewed, repaired, and developed (Karadağ, 2017). Sleep is a cornerstone of adolescent development. Although sleep duration varies, 8-10 hours per night is sufficient for adolescents <sup>[1]</sup>. Electronic media has a negative effect on the sleep of children and adolescents <sup>[2]</sup>. The total users of mobile phone are estimated to be increased to about 4.77 billion in 2017. About 75% of teenagers now own mobile phones. The mobile phone and smart phone ownership among teens has grown substantially since 2011. Fully 95 % of teens are online, a percentage that has been consistent since 2006. In many ways, teens represent the leading edge of mobile connectivity and the patterns of their technology use often signal future changes in the adult population. According to vision council the smaller devices which are to be held at 8 – 12 inches from the eyes foster the conditions for digital eye strain, characterized by blurred vision, eye fatigue, head neck and back pain. The various studies indicate that there may be relationship between daytime sleepiness and nocturnal mobile phone usage. The blue light from personal electronic devices has also been linked to serious physical and mental health problems. The direct exposure to blue light can cause damage to the retina. Light Emitting Diode (LED) is the basic lighting component in screens of phones, television sets, and computers. LED decreases the cellular viability by 75%-99%, increases cellular apoptosis by 66%- 89%<sup>1</sup>. The American Macular Degeneration Foundation warns that retinal damage caused by blue light may lead to macular degeneration which causes the loss of central vision. Some statistical evidence shows that mobile phone usage can lead to blurring of vision, secretions from eye, inflammation and lacrimation of eyes. Also there is decreased sperm count and testicular weight in rats which was exposed to electromagnetic radiations from 3G mobile phones <sup>[2]</sup>. Various studies are going on related to the cell phone addiction. It has become an indispensable part of the human life but this has crossed the point of necessity to the point of addiction.

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Thus it is high time we take necessary steps to bring the harmful effects of cell phone usage to lime light. The exposure to diffuse blue light for 3-6 hrs resulted in cell apoptosis which leads to early macular degeneration in rats [3]. It also suppresses the brain's production of melatonin, a hormone that helps to regulate the sleep cycle [4]. The increase in media use is associated with multiple negative outcomes including decreased sleep time and increased tiredness [5]. The smart phones ruin sleep and the associated health consequences that range from obesity to genetic disruption and memory problems [6]. Mobile phone usage has been associated with impairment of cognitive functions [7]. Mobile phones are widely used among young people, and the effect of this habit on their sleep quality is not well-known. This study was conducted to evaluate the effect of mobile phone usage on cognition and adolescents' sleep quality.

### Materials and Methods

An observational study was conducted among 80 volunteers aged between 18 and 24 years in the department of Physiology at Kakatiya medical college in Telangana, after obtaining Institutional Ethical Committee (IEC) clearance before commencement of the study. After obtaining the prior consent from the subjects, they were divided into 4 groups. Group 1: Non mobile phone users at night. Group 2: Nocturnal mobile phone users (< 1 hr per day). Group 3: Nocturnal mobile phone users (1 – 2 hrs per day). Group 4: Nocturnal mobile phone users (> 2 hrs per day). The subjects were selected by convenient sampling method and the selection was based on the following criteria. The subjects with history of organic brain disease likely to reduce cognition, prolonged hospitalization likely to reduce attention span and visual abnormality were excluded. Informed written consent was obtained from all the subjects prior to the study. An ID code was assigned for the subjects to maintain confidentiality of the data obtained. The following tests were performed to assess the cognitive functions:

**Mini mental status examination (MMSE):** It was done by asking a set of 11 questions under following section like orientation, registration, attention, calculation, recall and language.

**Digit symbol substitution test (DSST):** The test was done to assess neuropsychological activity of brain. It consists of (eg. one digit – symbol pair, 1/-, 7/^, 9/=) followed by a list of digits. Under each digit the subject should write down the corresponding symbol as fast as possible within 30 seconds.

**Letter Digit Substitution Test (LDST):** The test was done to assess cognitive function. It consists of (eg nine letter), digit pairs eg (w/1, b/2, t/3, p/4, v/5 ..... j/9) followed by list of alphabets. Under each alphabet, the subject must be instructed to write down the corresponding digit within 60 seconds of time period. The correct digit will be considered as a score.

**Wechsler memory scale- revised (WMS-R):** Two different tests were done in this type of cognitive function tests.

**(a) Spatial addition sub test:** It assesses visuo-spatial storage and manipulation in working memory. The examinee was shown a grid with blue or red dots on it for 5 seconds. They were asked to remember the location of the blue dots and ignore red dots that appear on page. The examinee was then shown a second page with blue and red dots for 5 seconds,

examinee then adds the two visual images together.

**(b) Design sub test:** The examinee was shown a page with designs placed in grid. There are 4 times having 4,6,6,8 designs for examinee to remember respectively. The examinee was asked to remember the designs and the location of designs. After seeing the stimulus page for 10 seconds, the examinee was given puzzle grid and cards with designs on them. The examinee must select the cards with correct designs and place them in puzzle grid in correct position. After 20-30 min of delay, the examinee was given the cards to place in the grid. Following the delay recall task, a delayed recognition is administered scores are calculated for total immediate, immediate content, immediate spatial, total delayed, delayed content and delayed spatial.

### Statistical analysis

Data were presented as mean  $\pm$  standard deviation. One way ANOVA test was performed to find whether scores of different groups differ significantly. To test inter group significant difference, by keeping group 1 as control, multivariate ANOVA test was performed. The data were analyzed by using SPSS 20.0 software. Statistical probability of  $P < 0.05$  was considered to be significant.

### Results

Table 1 shows that there was a significant decrease in DSST scores ( $P=0.04$ ) and LDST scores ( $P=0.05$ ) between groups 1 vs 2. The WMS 1 scores ( $P=0.01$ ) and WMS 2 scores ( $P=0.004$ ) were also significantly decreased between groups 1 vs 4. The PSQI scale scores were significantly increased ( $P < 0.0001$ ) between groups 1 vs 3 and 1 vs 4.

### Discussion

In our study, the scores of cognitive function tests decreased significantly in nocturnal mobile phone users and this change was more pronounced with more usage at night. In a study reported by Abramson *et al*, the overall mobile phone use was associated with faster and less accurate responding to higher level cognitive tasks [7]. On the contrary, Stalin *et al* reported that the exposure to electromagnetic fields of Global System for Mobile Communications, phone for 45 min in adults enhanced human cortical neural efficiency and simple cognitive- motor processes [8]. In a prospective cohort study conducted by Redmayne *et al*, in Australian primary school children, the use of mobile and cordless phones had an impact on cognitive functions [9]. The PSQI scale scores are significantly increased in groups 3 and 4 indicating a strong negative correlation between sleep quality and duration of mobile phone use at night. The blue light from personal electronic devices has also been linked to serious physical and mental health problems. The night time exposure to blue light emitted by smart phones, tablets, laptops and other LED screens may be damaging our vision. It also suppresses the production of hormone melatonin, a hormone that helps to regulate the sleep cycle. Bruch *et al* have reported that the prolonged use of cellular telephones may lead to reduced melatonin metabolite excretion, thus disrupting the sleep cycle [4]. In a study done by Smolensky *et al*, the routine exposure to artificial light at night leads to frequent nocturnal melatonin synthesis suppression and sleep wake cycle disruption with sleep deprivation [10]. In a study by Thomee *et al*, high mobile phone use was associated with sleep disturbances and symptoms of depression for both men and women [11]. Our finding was also supported by Loughran *et al*,

where mobile phone like emissions affect the EEG during non-REM sleep [12]. On the contrary, a study reported by Ahlers *et al.*, showed that radio frequency electromagnetic fields exposure at three mobile phone frequencies (GSM – 900, GSM-1800, Universal mobile Tele communication system) has no acute effects on mouse retinal ganglion cell responses under constant temperature condition [13]. The contrary finding was also reported by Demirel *et al* on effects of third generation mobile phone – emitted electromagnetic radiation on oxidative stress parameters in eye tissue and blood of rats, 3G mobile phone radiation does not lead to harmful effects on eye tissue and blood in rats [14]. The recently developed figures of merit for circadian luminous efficacy of radiation (CER) and circadian illuminance (CIL) related to human health and circadian rhythm were measured to compare 3 kinds of smartphone displays. The CIL values for social network service

messenger screens from all 3 displays were higher than 41.3 biolux in a dark room at night. The highest CIL values (50.9 biolux) correspond to melatonin suppression values [15].

### Conclusion

Sleep quality decreases as the duration of mobile phone usage increases. Young people prefer mobile phones over other media products because mobile phones are portable and include almost all the features and capabilities of other media products. The length of time adolescents spend with their mobile phone is a matter of concern for adolescents, and the use of mobile phones by children can cause health bad effects. Adults should make changes to regulate their sleep patterns. Mobile phones should be removed from the bedrooms. Families should control their children's intended use of mobile phone and its content and should limit the time spent with them.

**Table 1:** Cognitive function tests in nocturnal mobile phone users.

Group	MMSE	DSST	LDST	WMS1	WMS2
1	25.95±3.75	44.22±7.33	37.63±6.36	5.1±0.7	3.65±0.91
2	24.63±3.64	39.27±4.34	44.2±4.61	3.1±1.65	4.18±0.94
3	26.00±3.05	43.00±5.40	42.05±3.06	3.6±1.18	5.00±1.13
4	27.04±3.32	40.00±7.25	41.00±6.33	3.07±1.43	3.53±0.97
F test(P value)	0.104	0.147	0.198	0.097	0.004
1vs2 (P value)	0.98	0.04	0.05	0.09	0.11
1vs3 (P value)	0.95	0.12	0.43	0.37	0.8
1vs4 (P value)	0.67	0.11	0.76	0.01	0.004

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